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Prawn Fisheries of India

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CENTRAL MARINE FISHERIES RESEARCH INSTITUTE

Marine Fisheries P.O.

Mandapam Camp

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India

THE BULLETIN OF THE CENTRAL MARINE FISHERIES RESEARCH INSTITUTE IS PUBLISHED AT IRREGULAR INTERVALS AS AND WHEN INFORMATION OF A GENERAL NATURE BECOMES AVAILABLE FOR DISSEMINATION.

PREFACE

An attempt is made in this Bulletin to bring together concisely all the available information on the prawn fisheries of India. It was originally planned to be issued as part of a special publication of the Institute on the crustacean fisheries of the country, that would include the lobster and crab fisheries also. However, in view of the overwhelming and ever-increasing importance of the prawn fisheries it was felt desirable to bring out for immediate use an account that would give a perspective of this specific field alone and would serve as a work of reference for the interested research workers.

The knowledge we have gained on the biology and fishery of prawns of economic importance in India, mainly as a result of the investigations carried out at this Institute within the last two decades, is considerable. In recent years prawns have come to occupy a pre-eminent position in the fisheries complex in this country giving India a special status as the second among the important prawn-producing countries in the world. An export figure of 190 million rupees was reached in 1968 and the same is expected to exceed 250 million rupees during the current year. With the increasing importance of the commodity, scientific studies on the same could also rightly be expected to increase and the gradual accumulation of additional information would necessitate revision of the Bulletin at a later date.

The Symposium held at Cochin in January 1965 by the Marine Biological Association of India, and the World Meeting on the Biology and Fishery of Prawns and Shrimps held by the FAO in Mexico in June 1967, along with the Symposium on the Living Resources of the Seas around India organised by this Institute at Cochin in December 1968, have helped to bring together a great deal of information on the prawn

fisheries of the world including those of the Indian region. The Proceedings of the FAO World Meeting mentioned above are bound to serve as the most important reference for Prawn fishery biologists for a long time to come, but unfortunately in view of the limited number of copies issued they are not available for purchase thereby placing a good number of prawn research centres and interested workers there, especially in this region, in a disadvantageous position. Most of the relevant information contained in the above is incorporated in the appropriate chapters in this Bulletin and a comprehensive bibliography is also given so as to be of immediate use for research workers in the initial stages of their investigations.

My colleagues responsible for the preparation of the various chapters have done their best to make them as comprehensive and at the same time as concise as possible. My sincere thanks to all of them for the interest taken in the completion of this work and to other members of the staff for the co-operation extended in the issue of this Bulletin.

Mandapam Camp
August, 1969

S. JONES
Director
Central Marine Fisheries
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C O N T E N T S

I INTRODUCTION

By

S. Jones

(Central Marine Fisheries Research Institute, Mandapam Camp)

I INTRODUCTION

S. Jones

Prawns which are among the major marine fisheries have comprised 81,699 tonnes forming 10.5% in the total marine fish production of India estimated at an annual average of 777,733 tonnes in the ten year period of 1959-1968. About 85% of the prawn landings are from the west coast. Substantial quantities of prawns are also landed from backwaters, estuaries and coastal lagoons. In the prawn and shrimp production of the world which was 690,000 tonnes in 1967, the marine prawn catch of India formed about 13% . Taking the annual average of prawn production in the past one decade, among the major prawn producing countries, India has ranked next only to the United States of America.

Before the Central Marine Fisheries Research Institute initiated investigations, we had some general information on the taxonomy and distribution of the crustacean species on our coasts mainly through the works of Alcock, Anderson, Handerson, Kemp, Sewell and Wood-Mason which appeared about the close of the 19th century or the beginning of this century, but such biological information as would help promoting the prawn fishing industry was then lacking. Almost all the studies made till about the middle of this century were on museum specimens except for a few contributions of a casual or occasional nature touching on the fisheries.

In the past two decades this Institute has gathered considerable information on the age, growth rate, feeding, breeding and migration of the commercially important prawn species in our coastal and offshore waters and also on their regional distribution pattern and seasonal fluctuations. A fair knowledge of the movements of the larvae and juveniles of penaeid prawns from the open sea to the estuarine or brackish water environments and back to the sea for further growth, sexual maturity and spawning has been obtained. Spatial movements of the adult penaeids in relation to different depth zones have been correlated with specific diversity in their breeding habits. Catch trends are being checked in relation to fluctuations in potential stocks. Life histories have been traced in respect of some of the commercial varieties. A series of statistically designed field experiments have been conducted to elucidate factors promoting higher yields in prawn farming. Detailed studies have also been made in regard to palaemonid prawns, especially the giant brackish water prawn, Macrobrachium rosenbergii.

The inshore prawn fishery within the seven to ten mile coastal strip harvested by the indigenous, non-powered craft and gear has been in existence from the ancient times. The mechanisation of some of the craft has helped to extend the fishing zone a little farther. The exploitation of the deeper regions of the continental shelf and the slope using large and medium trawlers is very recent. The exploratory surveys in which this Institute participated with other organisations, have helped to report upon a large number

of prawn species not hitherto known from these waters. The most outstanding among the recent findings is the discovery of the occurrence of some of the pandalid prawn species on the continental slope in concentrations, dense enough to support a fishery of some magnitude.

Till about a decade ago India was trading with neighbouring countries in dry and cured shrimp fetching annually a few millions of rupees, but now she is among the world's foremost exporters in hygienically processed frozen or canned shrimp to countries like the United States, Japan etc. Shrimp and shrimp products amounting to over 18 thousand tonnes were exported in 1968 earning a foreign exchange of nearly 190 million rupees. While the internal consumption of prawns is pretty high for providing enough incentive to step up production, the demand from countries abroad for quality products has promoted advancement of the processing techniques. It is gratifying to find that the processing and export trade industry in prawn and prawn products has made rapid strides within a period of little over a decade mainly due to the pioneering efforts of a few industrialists of Kerala in and around Cochin, where some of the world's best fishing grounds are located.

The Symposium on Crustacea by the Marine Biological Association of India held in Cochin in 1965 and the FAO World Scientific Conference on the Biology and culture of Shrimps and Prawns in Mexico in 1967 have brought together a great deal of information on prawns and their fisheries, highlighting at the same time new or little known facts

regarding the world prawn resources and researches on them. Although both these symposia have been international in their outlook in dealing with the topics on a global basis, in the former the stress is more on the Indian work. In the proceedings of the FAO Conference at Mexico also a good many accounts have appeared on synopses of commercial species and on related topics pertaining to prawns of this region. A fair number of important contributions on prawns were presented at the Symposium on the Living Resources of the Seas around India organised by this Institute at Cochin in 1968. The access to all these works is not an easy matter to most of the scientific workers and others interested in the subject. In the chapters which follow a fairly detailed account is furnished on the economic varieties of prawns of this region, their life-histories, biology, distribution and fisheries, based almost entirely on the work turned out at this Institute. This publication aims at presenting a concise but comprehensive view of the present status of the prawn fishery of this country and the progress of scientific work so far achieved in this field.

II SYSTEMATICS - TAXONOMIC CONSIDERATIONS AND GENERAL DISTRIBUTION

By

M.J. George

(Central Marine Fisheries Research Institute, Mandapam Camp)

II SYSTEMATICS - TAXONOMIC CONSIDERATION AND GENERAL DISTRIBUTION

M.J. George

The prawns and shrimps of commerce of India belong to 3 major families, namely Penaeidae, Palaemonidae and Sergestidae of the decapod suborder Natantia. A few deep water forms belonging to the family Pandalidae are also gaining commercial importance with the result of recent exploratory fishing activities. There has been much confusion in the usage of the terms prawns and shrimps. At the Prawn Symposium of the Indo-Pacific Fisheries Council held at Tokyo in 1955 it was deoided that the term prawn should be applied to the Penaeids, Pandalids and Palaemonids, while the use of the term shrimp should be restricted to the smaller forms belonging to other families. According to this most of the forms of economic importance here are to be termed prawns.

In order to identify the prawn either in the field or in the laboratory a knowledge of certain morphological characters is highly essential. Figs. 1 and 2 are diagramatic representation of all these characters used in general in prawn systematics. Features of systematic importance are rostrum, carapace with the spines, carinae and sulcii, carination of the abdomen, telson, appendages, and secondary sexual characters like petasma and appendix masculina in male and thelycum in female.

Key to families consisting of commercially important forms.

1. Pleurae of second abdominal somite overlapping those of first and third segments; no chelae on 3rd pereopods. Gills phyllobranchiate 2
   Pleurae of 2nd abdominal somite overlapping those of 1st segment; third legs with a chela 4

2(1) Carpus of 2nd pair of pereopods divided into two or more articles; if not 1st pair of pereopods not chelate 3
   Carpus of 2nd pair of pereopods entire; no epipods on legs; upper antennular flagellum bifid; 3rd maxilliped normal . . . Palaemonidae

3(2) Chelae of 1st pair of pereopods distinct both sides; ends of fingers of this chelae usually dark coloured; eyes free, never extremely elongate . . . . Hippolytidae

Chelae of 1st pair of pereopods microscopically small or absent; chelae of 2nd pair of pereopods small and slender . . . . Pandalidae

4(1) Last two pairs of walking legs well developed; Gills many . . . . Penaeidae

Last one or two pairs of walking legs reduced or absent. Gills few or wanting .Sergestidae

Key to the commercial or potentially commercial species of prawns of the family Pandalidae

1. Carapace with longitudinal carinae on the lateral surfaces integument very firm. Pereopods of 2nd pair very unequal . . Heterocarpus . .

No longitudinal carinae on the carapace except for the postrostral crest; 3rd mxpd with exopod 2

2(1) Atleast the first 2 pereopods with epipods; postrerior lobe of Scaphognathite truncate styldcerite pointed anteriorly . . . . Plesionika 3

Pereopods without epipods; upper margin of rostrum finely and evenly serrate along its whole length; carpus of 5th leg shorter than propodus; minimum thickness of 6th abdominal somite, when looked at dorsally, 2/5 length of this somite, telson almost $1\frac{1}{2}$ as long as 5th somite . . . . Parapandalus spinipes

3(2) Posterior border of 3rd abdominal tergum acutely produced into a sharp tooth that overlaps the next tergum . . . Plesionika ensis

Posterior border of 3rd abdominal tergum though convex is not acutely produced; Rostrum 45 to 67 percent of the length of the body from orbit to tip of the telson. . . . . . Plesionika martia

4(1) Abdominal terga, though carinated, never produced posteriorly into overhanging spines; post ocular carina present; upper margin of rostrum proper armed with 2 or 3 teeth . . . . Heterocarpus gibbosus

3rd abdominal tergum armed with an acute spine arising from the anterior half postocular carina completely wanting . . . . Heterocarpus wood-masoni

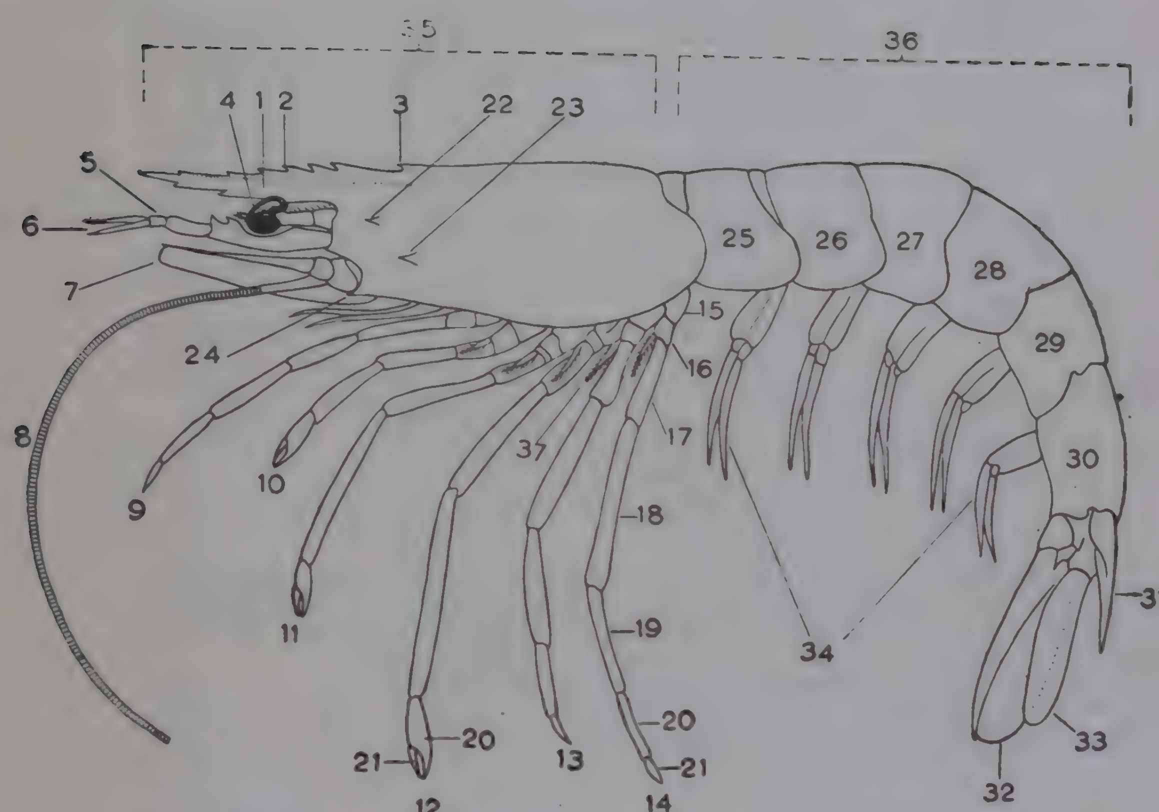
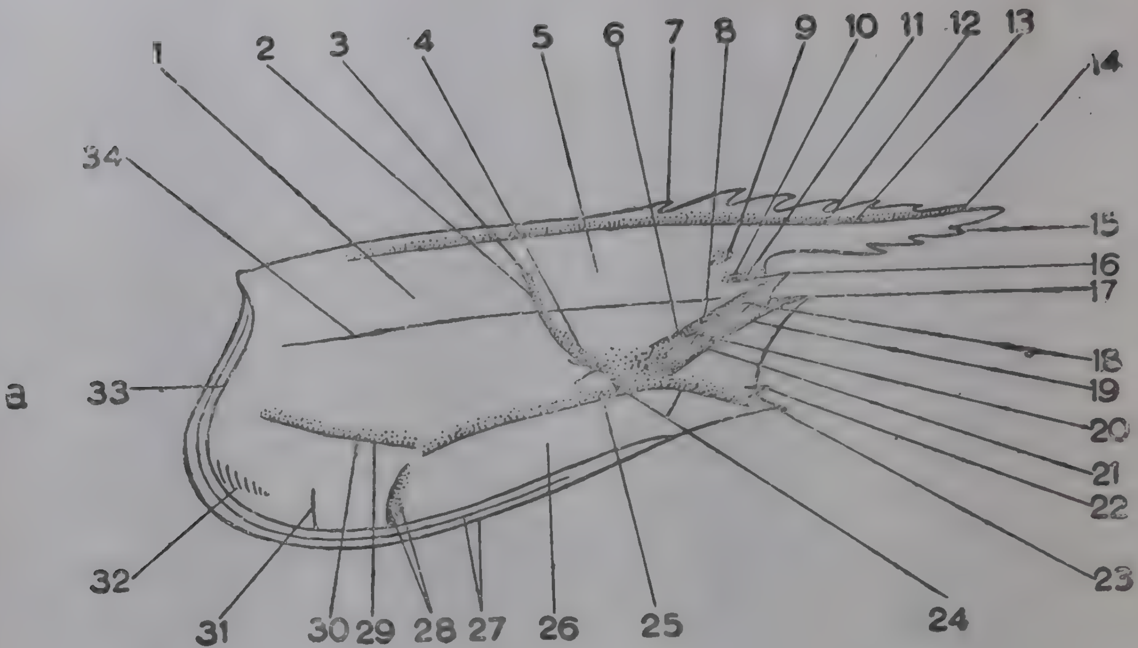


Fig. 1. Diagramatic drawing of a penaeid prawn to illustrate taxonomic characters. 1. Rostrum. 2. Rostral spines. 3. Epigastric spine. 4. Eye. 5. Antennule. 6. Antennular flagella. 7. Antennal scale. 8. Antennal flagellum. 9. Third maxilliped. 10–14. 1st-5th pereopods. 15. Coxa. 16. Basis. 17. Ischium. 18. Merus. 19. Carpus. 20. Propodus. 21. Dactylus. 22. Postorbital spine. 23. Hepatic spine. 24. Pterygostomian spine. 25-30. 1st-6th abdominal somites. 31. Telson. 32. Exopod of the uropod. 33. Endopod of the uropod. 34. Pleopods. 35. Carapace. 36. Abdomen.



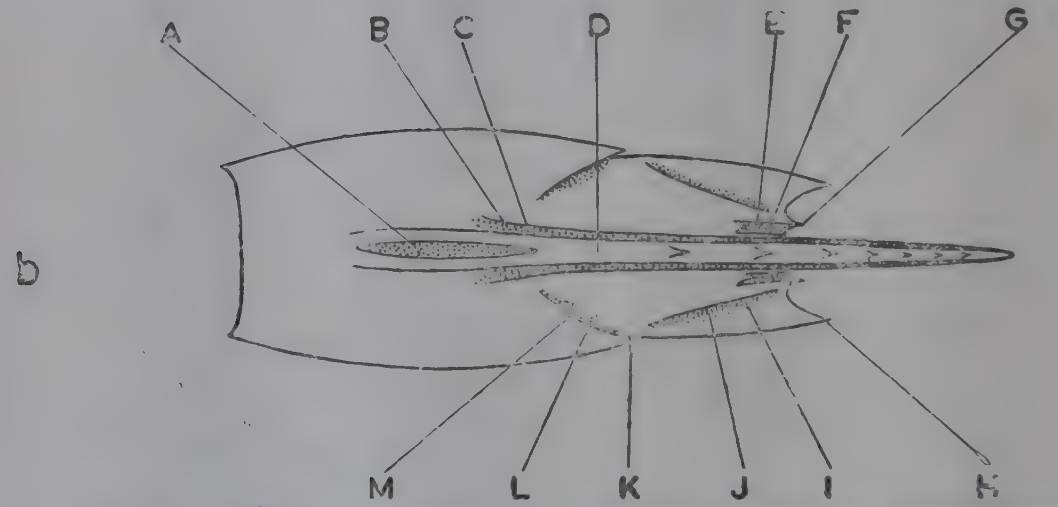


Fig. 2-a. Diagramatic representation of carapace to show features of taxonomic importance. 1. Cardiac region. 2. Cervical carina. 3. Cervical sulcus. 4. Hepatic spine. 5. Gastric region. 6. Gastro-orbital carina. 7. Epigastric spine. 8. Orbitoantennal sulcus. 9. Postocular sulcus. 10. Gastrofrontal sulcus. 11. Gastrofrotal carina. 12. Adrostral carina. 13. Adrostral sulcus. 14. Rostral tooth. 15. Ventral rostral tooth. 16. Orbital or supra-orbital spine 17. Antennal spine. 18. Postorbital spine 19. Antennal carina. 20. Post antennal spine 21. Orbito-antennal sulcus. 22. Branchiostegal spine. 23. Pterygostomian spine. 24. Hepatic carina. 25. Hepatic sulcus. 26. Pterygostomian region. 27. Marginal region. 28. Inferior carina and sulcus. 29. Branchiocardiac carina. 30. Branchiocardiac sulcus. 31. Transverse suture. 32. Stridulating organ. 33. Pterygostomian sulcus. 34. Longitudinal suture.

Fig. 2-b. A. Postrostral or median sulcus. B. Adrostral sulcus. C. Adrostral carina. D. Postrostral carina. E. Gastrofrontal carina. F. Gastrofrontal sulcus. G. Orbital or Supra-orbital spine. H. Antennal spine. I. Gastroorbital carina J. Orbito-antennal sulcus. K. Hepatic spine. L. Cervical sulcus. M. Cervical carina.

Family Hippolytidae

Genus Hippolysmata

1. Rostrum shorter than carapace, without elevated basal crest; lateral margins of telson convex, apex blunt with a pair of spines . . . . *Hippolysmata vittata*

2. Rostrum longer than carapace, with an elevated dentate basal crest; lateral margins of telson concave, apex acute and unarmed . . . . *Hippolysmata ensirostris*

Key to commercially important coastal species (family Palaemonidae)

1. Branchiostegal spine present; mandible with a palp; eyes distinctly pigmented; first pleopod of male without or with a rudimental appendix interna on the endopod; branchiostegal spines present as a sharp line; propodus of 5th pereopod with transverse rows of sitae on the distal part of the posterior margin; the two median hairs of the posterior margin of telson are slender . . . Palaemon . . . 2
   Branchiostegal spine absent; hepatic spine present; dactylus of last 3 legs simple . . . . Macrobrachium 3

2(1) Dactylus of last three pereopods very long and slender; 4th and 5th pair excessively long, flagelliform with dactylus much longer than carapace; pleopods very long; 1st pair much longer than carapace, carpus of 2nd pereopod much more than half as long as palm; basal crest of rostrum with atmost 7 teeth . . . . *Palaemon tenuipes*
   Dactylus of last three pereopods not abnormal in length that of 3rd scarcely ½ length of propodus and that of 5th atmost 1/3 length of propodus. Pleopods normal in length, one or more subapical dorsal teeth on rostrum. Last four abdominal somites bluntly carinate dorsally . . . . *Palaemon styliferus*

3(1) Carpus of 2nd pereopod longer than merus 4
   Carpus of 2nd pereopod about as long as or shorter than merus 10

4(3) Rostrum with a distinct elevated basal crest, generally very long or with a distinct naked portion in the distal half of the upper margin 5
   Rostrum without a distinct elevated basal crest 8

5(4) Tips of telson reaching beyond the tip of the longer posterior spines 6

Tips of telson overreached by the longer posterior spines; rostrum generally straight; distal part of rostrum without dorsal teeth 7

6(5) Carpus of the 2nd pereopod in adult male slightly longer than half as long as chela; fingers of that leg of the same length as the palm . . . . <u>Macrobrachium</u> <u>rosenbergii</u>

Carpus of the 2nd pereopod in adultmale as long as, slightly longer or slightly shorter than chela; fingers of that leg a little less than half as long as the palm . . . <u>Macrobrachium</u> <u>villosimanus</u>

7(5) Basal crest not much elevated, provided with 5-9 teeth palm of 2nd leg not swollen, fingers shorter than palm . . . . <u>Macrobrachium</u> <u>lamarrei</u>

Basal crest distinctly elevated, provided with 5-9 teeth. In young specimen the 2nd leg has the palm swollen and the fingers longer than the palm. Carpus of 2nd leg in adult male shorter than chela . . . . <u>Macrobrachium</u> <u>malcolmsonii</u>

8(4) Large chela of 2nd leg of adult male with tubercles at both sides of the cutting edges. Carpus of 2nd leg in adult male shorter than chela. All joints of 2nd legs in adult male pubescent . . . . <u>Macrobrachium</u> <u>rude</u>

Large chela of 2nd leg of adult male without tubercles at each side of the cutting edges 9

9(8) Rostrum with 9-11 teeth dorsally, 3 of which generally placed behind the orbit. Carpus of 2nd leg in adult male larger than chela . . . . <u>Macrobrachium</u> <u>idae</u>

Rostrum curved upwards and lower margin with 5-7 (seldom 4) teeth. Fingers covered with stiff or velvetty hairs on the entire surface or in the proximal part . . . <u>Macrobrachium</u> <u>equidens</u>

10(3) Fifth legs conspicuously (about 4/3) longer than the 4th; rostrum short and high with many dorsal teeth. Second legs of adult male smooth . . . . <u>Macrobrachium</u> <u>mirabile</u>

Fifth legs of about the same length as the fourth 11

11(10) Fingers of 2nd legs of adult male with 1 or 2 fairly large teeth. Smaller teeth may be present between the first tooth and the base of the fingers; anterior tooth of the dactylus placed in or slightly before the middle of the finger . . . . *Macrobrachium javanicum*

Fingers of 2nd legs of adult male with more than 4 teeth placed at regular intervals, sometimes restricted to the proximal part. Teeth are generally of equal size, but one of the proximal teeth may sometimes be larger. Fingers with a ~~xx~~ ~~velvetty~~ pubescence in ~~their basal~~ portion. Dorsal teeth of the rostrum beginning in the distal third of the carapace . . . . *Macrobrachium scabriculum*

Family Sergestidae

Genus Acetes

1. Procurved spine present between 1st pair of pleopods 2

No procurved spine between 1st pair of pleopods 3

2(1) Trochanter (basis) of 3rd pereopod with tooth on inner free margin; petasma without membraneous coupling folds . . *Acetes indicus*

Trochanter (basis) of 3rd pereopod without tooth on inner free margin; petasma with a pair of folded coupling membranes armed with hooks . . . . *Acetes erythraeus*

3(1) External antennular flagellum in male with two clasping spines; apex of telson rounded or truncated 4

External antennular flagellum in male with single clasping spine; apex of telson triangular . . . . *Acetes sibogae*

4(3) Segment preceding the one bearing the clasping spines with angular process pointing backwards; apex of telson truncated and with a tooth at each corner . . . . *Acetes serrulatus*

Segment preceding the one bearing the clasping spines without any process; apex of telson round and third thoracic sternite produced posteriorly as large plate in female 5

5(4) Ciliated and non-ciliated portions of external border of exopod of uropod not separated by a tooth; distal portion of pars externa without tubercles . . . . *Acetes japonicus*

Ciliated and non-ciliated portions of external border of exopod of uropod separated by a tooth; distal portion of pars externa with tubercles . . . . *Acetes cochinensis*

Key to the commercial or potentially commercial species of prawns of the family Penaeidae

1 Post orbital spine present. Subfamily Solenocerinae 4
Post orbital spine absent 2

2(1) Carapace with a median dentate crest extending nearly or quite to the posterior margin. Subfamily Sicyoninae 8
Carapace without a median dentate crest except occasionally over the eyes 3

3(2) Distinct median tubercle on occular peduncle; upper antennular flagellum inserted near posterior border of third antennular segment, strikingly shorter than other . . . subfamily Aristaeinae..9
No distinct median tubercle on occular peduncle; upper antennular flagellum subequal to the lower one attached to apex of third antennular segment . . . . Subfamily Penaeinae 12

4(1) Antennular flagella foliaceous; post orbital spine absent . . . . Solenocera 5
Antennular flagella cylindrical or subcylindrical; post orbital spine present . . . . Hymenopenaeus

Rostrum straight, inclined upwards at an angle of 20° with 7-8+2 teeth dorsally . . . . . . Hymenopenaeus aequalis (Bate)

5(4) Telson trifurcate 6
Telson simple and devoid of any spine on lateral margin . . . . . Solenocera indica Nataraj

6(5) Externo distal margin of the exopod of the uropod with spine . . 7
Externo distal margin of the exopod of the uropod without spine; post rostral carina not extending beyond cervical groove. . . . . Solenocera pectinata (Bate)

7(6) Spine on the cervical groove ventral to the posteriormost spine of the rostral series present ;'L' shaped groove on either branchiostegal region present . . . . Solenocera haxtii
Spine on the cervical groove ventral to the posteriormost spine of the rostral series absent; 'L' shaped groove on either branchiostegal region absent . . . . . . Solenocera choprai Nataraj

8(2) Post rostral carina armed with 5 teeth; abdominal pleura of 1st and 2nd segments unispinose and 3rd, 4th and 5th with 3 spines. . . . . <u>Sicyonia</u> <u>lancifer</u> (Olivier)

9(3) Rostrum three-toothed dorsally; hepatic spine absent . . . . <u>Aristeus</u> 10

Rostrum with many teeth on upper border; hepatic spine present; length of pterygostemian region more than 2.5 times its greatest breadth . . . . <u>Aristaeomorpha</u> <u>woodmasoni</u> Calman

10(9) Integument glabrous 11

Integument pubescent . . . . <u>Aristeus</u> <u>virilis</u> (Bate)

11(10) Pleurobranchiae on segments X-XIII on distinct filaments provided with pinnules . . . . <u>Aristeus</u> <u>semidentatus</u> (Bate)

Pleurobranchiae on segments X-XIII reduced to mere papillae . . . . <u>Aristeus</u> <u>alcocki</u> Ramadan

12(3) Rostrum without ventral teeth 13

Rostrum with ventral teeth . . . . <u>Penaeus</u> 19

13(12) A distal fixed pair of spines on the telson and 1-3 pairs of mobile spines 14

No distal fixed pair of spines on the telson; lateral mobile spines may be present 16

14(13) Petasma symmetrical; 3rd maxilliped without basial spine . . . 15

Petasma asymmetrical; 3rd maxilliped with basial spine . . . . <u>Metapenaeopsis</u> 26

15(14) Carapace with longitudinal sutures extending from post orbital margin to almost posterior margin . . . . <u>Parapenaeus</u> 30

Carapace without longitudinal sutures; branchiostegal spine present . . . . <u>Penaeopsis</u>

Telson with 3 pairs of movable marginal spines in addition to the fixed pair . . . . <u>Penaeopsis</u> <u>rectacuta</u> (Bate)

16(13) No exopod on 5th pereopod; pleurobranch on 7th thoracic somite present . . . . <u>Metapenaeus</u> 32

Exopod on 5th pereopod present; pleurobranch on 7th thoracic somite absent 17

17(16) Carapace with longitudinal sutures; ischial spine on 2nd pereopod absent 18
Carapace without longitudinal sutures; ischial spine on 2nd pereopod present . . . . Atypopenaeus
Hepatic spine present; petasma not constricted distally; anterior plate of thelycum rounded posteriorly . . . . *Atypopenaeus stenodactylus* (Stimpson)

18(17) 3rd pereopod with epipodite . . . . *Trachypenaeus* . . . 41
3rd pereopod without epipodite . . . . . *Parapenaeopsis* . . . 43

Penaeus

19(12) Adrostral carina reaching almost to posterior border of carapace; gastrofrontal carina present 20
Adrostral carina not reaching behind middle of carapace; gastrofrontal carina absent 22

20(19) Telson armed usually with 3 pairs of spinules 21
Telson unarmed; rostrum with 1 ventral tooth . . . . *Penaeus canaliculatus* Olivier

21(20) Adrostral sulcus narrower than post rostral carina; anterior plate of thelycum rounded at the apex . . . *Penaeus japonicus* Bate
Adrostral sulcus as wide as post rostral carina; anterior plate of thelycum bifid at the apex . . . *Penaeus latisulcatus* Kishinouye

22(19) Hepatic carina present 23
Hepatic carina absent 24

23(22) Hepatic carina horizontally straight; 5th pereopod without exopodite . . . . *Penaeus monodon* Fabricius
Hepatic carina inclined at an angle of 20° anteroventrally; 5th pereopod with small exopodite ... *Penaeus semisulcatus* de Haan

24(22) Gastro orbital carina occupying the posterior 2/3 distance between hepatic spine and orbital angle; Rostral crest may be elevated but not triangular in profile . . . *Penaeus indicus* Milne Edwards
Gastro orbital carina absent or not reaching hepatic spine and occupying the middle 1/3 distance between hepatic spine and orbital angle 25

25(24) Dactyl of 3rd mxpd. of adult ♂ ½ propodus; adrostral carina not reaching as far as epigastric tooth; rostral crest triangular in profile . . . . *Penaeus merguiensis* de Man

Dactyl of 3rd mxpd. of adult ♂ much longer than propodus; adrostral carina reaching just beyond epigastric tooth; rostral crest markedly elevated . . . . *Penaeus penicillatus* Alcock

Metapenaeopsis

26(14) Stridulating organ present on posterior branchiostegite 27

Stridulating organ absent from posterior branchiostegite . . .28

27(26) Dorsal carina of 3rd pleonic somite sulcate; stridulating organ almost straight; anterior edge of thelycal plate entire, left petasmal lobe sharply pointed and triangular . . . . *Metapenaeopsis stridulans* Alcock

28(26) A pair of tooth-like platelets behind thelycal plate, posterior tubercles lacking . . . . . *Metapenaeopsis mogiensis* (Rathbun)

No teeth like platelets immediately posterior to thelycal plate 29

29(28) Posterior extension of thelycal plate with indistinct median sulcus and angular posterolateral corners . . . . *Metapenaeopsis andamanensis* (Wood-Mason & Alcock)

Posterior extension of thelycal plate with distinct median sulcus and evenly rounded posterolateral corners . . . . *Metapenaeopsis philippii* (Bate)

Parapenaeus

30(15) Branchiostegal spine present; 5th pereopods not reaching tip of antennal scale 31

Branchiostegal spine absent; 5th pereopods exceeding antennal scale by dactyl . . . . *Parapenaeus longipes* Alcock

31(30) Branchiostegal spine on anterior margin of carpace; 6th abdominal somite less than twice length of 5th; process 'a' of petasma bifurcate, directed laterally;thelycum with anterior, intermediate and posterior plates . . . . *Parapenaeus fissurus* (Bate)

Branchiostegal spine a little behind anterior margin of carapace; 6th abdominal somite more than twice length of 5th; rostrum reaching distal end of 1st segment of antennular peduncle . . . . <u>Parapenaeus</u> <u>investigatoris</u> Alcock

<u>Metapenaeus</u>

32(16) Distomedian petasmal projection with fully developed or vestigial apical filament; thelycum of impregnated females usually with white conjoined pads 33
Distomedian petasmal projection without apical filament; thelycum of impregnated females without white conjoined pads . . 35

33(32) Rostrum wide and short, not reaching to distal end of basal antennular segment; thelycum with ovoid anterior and lateral plates of subequal size; conjoined pads usually set askew; apical filaments of petasma vestigial represented by a pair of rounded bosses . . . . <u>Metapenaeus lysianassa</u> (de Man)
Rostrum projecting beyond basal antennular segment, with a marked edentate distal portion 34

34(33) Posterior part of rostrum with distinctly elevated crest; basial spine on ♂ 3rd pereopod simple; ~~apa~~ apical petasmal filaments slender slightly converging; thelycum with a large anterior and small lateral plates . . . . . <u>Metapenaeus</u> <u>brevicornis</u> (Milne Edw.
Posterior part of rostrum without distinctly elevated crest; basial spine on ♂ 3rd pereopod long and barbed; apical petasmal filaments not readily visible; anterior thelycal plate tongue-like . . . . <u>Metapenaeus</u> <u>dobsoni</u> (Miers)

35(32) Branchiocardiac sulcus distinct in at least posterior 1/3 carapace; distomedian petasmal projections flap-like 36
Branchiocardiac sulcus almost completely absent; distomedian petasmal projections anteriorly filiform each with a serrate ventral margin. . . . . <u>Metapenaeus stebbingi</u> (Nobili)

36(35) Ischial spine on 1st pereopod distinct 37
Ischial spine on 1st pereopod small or absent 40

37(36) Distomedian petasmal projections directed anteriorad; lateral thelycal plates with raised lateral ridges, each with a posterior inwardly curved triangular plate . . <u>Metapenaeus</u> <u>ensis</u> (de Haan)

Distomedian petasmal projections directed anterolaterally; anterior thelycal plate tongue-like 38

38(37) Lateral thelycal plates with salient and parallel earshaped lateral ridges; distomedian petasmal projections hood-like . . . . <u>Metapenaeus</u> <u>monoceros</u> (Fabricius)

Lateral thelycal plates without lateral raised ridges; distomedian petasmal projections not hood-like 39

39(38) Posterior extension of the anterior median thelycal plate bound laterally by an oval flat plate on each side; distomedian petasmal projections overlying lateral projections and distally trilobed . . . . <u>Metapenaeus</u> <u>alcocki</u> George & Rao

Posterior extension o. the anterior median thelycal plate not boun.. laterally by oval plate on either side; distomedian petasmal projections not overlying lateral projections . . . . <u>Metapenaeus</u> <u>kutchensis</u> George, George and Rao

40(36) Branchiocardiac carina distinct, extending from posterior margin of carapace almost to hepatic spire; anterior thelycal plate longidudinally grooved, wider posterirly than anteriorly; distomedian petasmal projections crescent shaped . . . . <u>Metapenaeus</u> <u>affinis</u> (Milne Edw.)

Branchiocardiac carina feeble or ill-defined, anterior end not exceeding posterior 1/3 of carapace; distal margin of anterior thelycal plate conv... indistinctly triangular; petasma with laminose and strongly diverging distomedian projections . . . . <u>Metapenaeus</u> <u>burkenroadi</u> Kubo

<u>Trachypenaeus</u>

41(18) Epipodites present on 1st and 2nd pereopods 42

Epipodites absent on 1st and 2nd pereopods; distolateral projections of petasma with sharp tips reaching coxae of 4th pereopods; anteolaterally with large wing-like flaps on outer curvature . . . . . . <u>Trachypenaeus</u> <u>pescadoreensis</u> Schmitt

42(41) The plates of thelycum with raised anterior and lateral margins . . . . Trachypenaeus sedili Hall
The anterior plate of the thelycum may have a raised anterior
margin but laterally the margins are not raised; an excavation present between the anterior plate and the transverse sternal ridge . . . . . . Trachypenaeus curvirostris (Stimpson).

Parapenaeopsis

43(18) Epipodites present on 1st and 2nd pereopods 44
Epipodites absent on 1st and 2nd pereopods 49

44(43) 2nd pereopods with basial spines 45
2nd pereopods without basial spines . . . .
. . . . . Parapenaeopsis uncta (Alcock)

45(44) Telson with pair of fixed subapical spines; at least distal ½ free portion of rostrum unarmed . . . .
. . . . . Parapenaeopsis stylifera (Milne Edw.)
Telson without fixed subapical spines, with or without lateral movable spines; 1/3 or less free portion of rostrum unarmed . . 46

46(45) Petasma with a pair of distolateral projections directed laterally or distolaterally, usually short and spout-like . . . 47
Petasma with pair of long slender caliper-like distolateral projections directed forwards; thelycum with median tuft of long setae behind posterior edge of last thoracic sternite; third pereopod of ♀ with basial spine . . . .
. . . Parapenaeopsis cornuta maxillipido (Alcock)

47(46) Postrostral carina reaching almost to posterior border of carapace; petasma with pair of short spout-like distolateral projections and pair of cap-like distal projections 48
Postrostral carina reaching 3/4 carapace; petasma with pair of distolateral projections directed laterally, cap-like ~~pro~~ distal projections absent. . . . Parapenaeopsis nana (Alcock)

48(47) Antennular flagella 0.5-0.6 length of carapace; thelycum with median tuft of setae on posterior plate . . . .
. . Parapenaeopsis sculptilis (Heller)

Antennular flagella 0.7 length of carapace or longer; thelycum without a median tuft of setae on posterior plate . . . . *Parapenaeopsis hardwickii* (Miers)

49(43) Anterior plate of thelycum with V shaped posterior edge; and 2 accessory ridges on anterior edge of posterior plate; rostrum with proximal 1/3 rising from carapace; remainder more or less horizontal . . . . *Parapenaeopsis tenella* (Bate)

Anterior plate of thelycum with a more or less straight transverse posterior edge; no accessory ridges on anterior edge of posterior plate; rostrum inclined upwards at an angle to carapace for whole of its length . . . . *Parapenaeopsis acclivirostris* (Alcock)

Family *Penaeidae* Rafinesque

Among the penaeid prawns there are about 48 species belonging to different subfamilies and genera found in the coastal waters of India. Excepting for a few forms both form the deeper waters as well as coastal inshore waters, most of these are of commercial importance at some part of the coast or other. Details regarding their systematic position and distribution are as follows:-

Subfamily *Solenocerinae* Wood-Mason & Alcock 1891

Solenocera Lucas 1850

Solenocera indica Nataraj 1945

Solenocera kuboi Hall, 1956: 69-71.

Solenocera subnuda Kubo, 1949: 255-260; Cheung 1959: 224; Cheung 1960: 68; 1963: 401-433; Hall 1962: 11-12; de Bruin, 1965:74.

Solenocera indicus Nataraj 1945: 94; Ahmed 1957.

Solenocera indica Kunju 1967: 1-12.

The species has a distribution in the Indo-Pacific from East Pakistan waters, along Indian coasts and Ceylon to Malaysia, Borneo and Hong Kong. In Indian waters it is found along both west and east coasts. On the west coast in Bombay waters the species contributes to a fishery (Kunju, 1967). While most of the species of Solenocerinae are deep water forms, *S. indica* is a littoral species inhabiting waters of 40 m and less.

Solenocera pectinata (Bate, 1888)

Philonicus pectinatus Bate 1888: 279.

Philonicus cervicalis Zehntner 1894: 210.

Solenocera pectinata de Man 1911: 45-47; Anderson and Lindner 1943: 286 (in Key); Nataraj 1945: 96; Hall 1961: 80; 1962: 13; 1966: 98; George 1967: 337.

Solenocera pectinulata Kubo 1949: 251-255.

This has been recorded from Arafura Sea, Flores Sea, Ceram Sea, off Owase, Japan, Arabian Sea, Tenasserem Coast, Bumma and South China Sea. In Indian waters the species has been obtained in trawl nets operated in Arabian Sea off south west coast in depths from 25-60 fathoms. It is recorded in small numbers and at present does not contribute to any fishery. Size also is too small to be of any commercial significance.

Solenocera hextii Wood-Mason 1891

Solenocera hextii Wood-Mason 1891: 275; Alcock 1901: 20-21; de Man 1911:7; Ramadan 1938: 56; Anderson and Lindner 1943: 286 (in Key) George 1967: 338.

The species has a general geographic distribution in the northern Indian Ocean regions. On the Indian coast it has a distribution along the entire west coast and also in the Bay of Bengal. It is a fairly deep water form recorded from 65 to 276 fathoms. The recent exploratory trawling operations off the south west coast of India in 150 to 200 fathoms areas caught this species in varying numbers; but never in very large quantities. The larger size of the species is particularly attractive to commerce.

Solenocera choprai Nataraj 1945

Solenocera choprai Nataraj 1945: 91.

This is a species which has been recorded so far only from the type locality which is Arabian Sea (17°27'N, 71° 41'E) from depths of 56 to 58 fathoms.

Solenocera koelbeli de Man 1884

Solenocera distincta Koelbel 1884: 314; Balss 1914: 5-6
Solenocera koelbeli de Man 1911: 48; Anderson and Lindner 1943: 286 (in Key); George 1967: 338.

Outside the type locality of the species in Japan, this is only recorded from the Arabian Sea off south west coast of India and that in very small numbers. Depth from which the species is recorded in India is from 35-40 fathoms.

Solenocera melantho de Man 1907

Solenocera melantho de Man 1907: 137; 1911: 48-52; Hall 1961: 78-79; Hall 1962: 12; Ganapathi & Subramanyam 1966: 12.
Solenocera depressa Kubo 1949: 237-40.

Having a distribution in the East Indian Archipelago, Malaysia and Japan, the species has been recently reported from the east coast of India near the Godavari estuarine system in comparatively shallow waters. Here it is found in small numbers along with other commercially important penaeids.

Hymenopenaeus aequalis (Bate 1888)

Haliporus equalis Bate 1888: 285-286.
Haliporus aequalis de Man 1911: 32-33.
Hymenopenaeus aequalis Kubo 1949: 219-222 (with synonymy); George 1967:339.

The species has a fairly wide distribution in the Indo-Pacific, extending from east coast of Africa along the Indian seas to Japan. In Indian waters it is found on the west coast off south west and also on the east coast in Andaman Sea. All the records are from above 150 fathoms.

Sicyoninae

Sicyonia lancifer (Olivier 1811)

Sicyonia lancifer de Man 1911: 123-124 (with synonymy); Hall 1961: 112; 1962: 37; George 1967: 344.
Eusicyonia lancifer Kubo 1949: 439-444; Kurian 1953: 761.

This species is distributed in Japan, Penang, the pearl banks of

Gulf of Mannar, Ceylon and south west coast of India. From the Arabian Sea it is reported in very small numbers from 12-17 fathoms depth.

Aristaeinae

Aristeus semidentatus (Bate 1888)

Hemipenaeus semidentatus Bate 1888: 305.

Aristeus semidentatus de Man 1911: 29-31; Ramadan 1938: 40; George 1967: 339-340 (with synonymy).

Till recently the species was known only from the areas near Kermadec Islands and Kei Islands. The recent exploratory shrimp trawling operations in deeper waters (150-200 fathoms) off Cochin and Alleppey on the south west coast of India caught this species among others in fairly large numbers from certain areas in that zone. This is the largest among the prawns caught in these operations and is of great potential importance commercially.

Aristeus alcocki Ramadan 1938

Aristeus semidentatus Alcock 1901: 31; Kemp and Sewell 1912: 19.

Aristeus alcocki Ramadan 1938: 40-42; George 1967: 340.

Gulf of Aden, Bay of Bengal and Arabian Sea near the Laccadives and Cape Comorin are the three localities from which the species is recorded. Unlike thexx previous species this is found in small numbers in the recent exploratory trawl catches off south west coast of India.

Aristeus virilis (Bate 1881)

Hemipenaeus virilis Bate 1881: 187; 1888: 303.

Hemipenaeus tomentosus Bate 1881: 189; 1888: 307.

Aristaeus virilis Wood-Mason 1891: 279; Alcock 1901: 30; Bouvier 1908:70; Kubo 1949:194-200.

Aristeus virilis de Man 1911: 27-29; Ramadan 1938: 39-40.

General distribution of the species in the Indo-Pacific extends from the Andamanx Sea through the East Indian Archipelago to Japan. In the Andaman sea it is found in depths of 188 to 405 fathoms.

Aristaeomorpha woodmasoni Calman 1925

Aristeomorpha woodmasoni Calman 1925: 8 (with synonymy); Burkenroad 1936: 85; Ramadan 1938: 53.

Aristaeomorpha rostridentata Kubo 1949: 206.

Aristaemorpha woodmasoni Barnard 1950: 627.

Apart from Indian waters Bay of Bengal, Andaman Sea and Arabian Sea the species is recorded only from South East Australia. In Indian waters the depth from which it is recorded ranges from 180 to 271 fathoms.

Penaeinae

Penaeus canaliculatus Olivier 1811

Penaeus canaliculatus Olivier 1811: 660; Milne Edwards 1837:414; Bate 1881: 174 and 1888:243; Nobili 1906:9; de Man 1911: 106-107; Barnard 1950:590; de Bruin 1965:75; Joubert 1965: 18-20; Hall 1966:98.

Peneus canaliculatus of Alcock (1906) being later synonymised as P. japonicus Bate, most of the records of P. canaliculatus from Indian waters may be referred to P. japonicus. However P. canaliculatus auct. has recently been obtained in few numbers among the prawn collections from south west coast of India, although it ~~xxxxx~~ does not contribute to a fishery. General distribution of the species is South Africa, Mauritius and Red Sea through Indian Seas to East Indies and Fiji Islands. The maximum size attained by the species is about 150 mm.

Penaeus japonicus Bate 1888

Penaeus canaliculatus var japonicus Bate 1888: 245-248.

Penaeus canaliculatus Ortmann 1890: 488; Kishinouye 1900:11-12; Rathbun 1902:37; Nataraj 1942:468; Menon 1956:345 (Key).

Peneus canaliculatus Alcock 1906: 14-16 (part synonymy only).

Penaeus japonicus Nobili, 1906:10; de Man 1911:107; Balss 1914: 13; Kubo 1949:273-78; Barnard 1950:590-92; Hall 1956:71; 1962:14; 1966:98; Ahmed 1957; Dall 1957:142 (in Key); Racek and Dall 1965:12; Cheng-Ming 1965:2; Joubert 1965:15-16; Ganapathi and Subramanyam 1966:12; Tirmizi 1967:5.

This is widely distributed throughout the greater part of the Indo-West-Pacific, from Africa to Fiji. In Indian waters it makes a small contribution to the fishery along the Madras coast especially in Pulicat

Lake and on the west coast occurs in small numbers in Bombay and other places, Maximum size up to 27 cm in length. On the east coast it occurs in the fishery in the post-monsoon months.

<u>Penaeus</u> <u>latisulcatus</u> Kishinouye 1900

<u>Penaeus</u> <u>latisulcatus</u> Kishinouye 1900:12; de Man 1911:108-11; Kubo 1949: 278-82; Racek 1955:222-23; Hall 1956:72; 1962:14-15; 1966:98; Dall 1957:149-151; Racek and Dall 1965:12-13; de Bruin 1965: 75-75; Cheng-Ming 1965:3; Joubert 1965:17-18.

<u>Peneus</u> <u>latisulcatus</u> Schmitt 1926: 365-67.

<u>Penaeus</u> <u>canaliculatus</u> var. <u>australiensis</u> de Man 1902: 905.

Scattered distribution from Red Sea through Malaysia and the Mollucсas to Korea and Japan. So far the species was not reported from Indian waters. One or two specimens were obtained recently from the south west coast collection and it is now reported for the first time from India.

<u>Penaeus</u> <u>monodon</u> Fabricius 1798

<u>Penaeus</u> <u>monodon</u> Fabricius 1798:408; Haswell 1882:199; Kishinouye 1900: 7&15; Stebbing 1910:380; Holthuis 1949:1051-57; Kubo 1949: 291 (part synonymy only); Barnard 1950:584; Dall 1957: 152-154; Racek and Dall 1965: 10-11; de Bruin 1965:76; Cheng-Ming 1965:1; Joubert 1965:22-24; Hall 1966:98; Tirmizi 1967:7.

<u>Penaeus</u> <u>carinatus</u> Dana 1852:602; de Man 1911:101; Kemp 1915:317; Burkenroad 1934:74; Nataraj 1942:468; Anderson and Lindner 1943:305; Racek 1955:215-17; Menon 1956:345 (Key).

<u>Peneus</u> <u>semisulcatus</u> Alcock 1906:10-11.

<u>Penaeus</u> <u>caeruleus</u> Stebbing 1905:77; Burkenroad 1934:74; Racek 1955:217-218.

<u>Peneus</u> <u>carinatus</u> Schmitt 1926:359 & 363.

<u>Penaeus</u> <u>bubulus</u> Kubo 1949: 296-301.

This is one of the penaeid species which is widely distributed throughout the greater part of the Indo-West-Pacific region ranging from South Africa to southern Japan apparently preferring warm water habitats. Along the Indian coast it is more common on the east coast especially in the northern section (Bengal and Orissa) where it contributes to a fishery. On the west coast of India although not forming a dominant fishery anywhere large sizes are caught in good numbers mostly in the northern section.

This is the largest Indian marine prawn attaining a maximum of 300-320 mm in length. As in other commercially important penaeid prawns breeding takes place in the sea and the juveniles enter estuaries, backwaters and lakes.

Penaeus semisulcatus de Haan 1850

Penaeus semisulcatus de Haan 1850:191; de Man 1911:97-100; Barnard 1950: 588; Racek 1955:218-19; Ahmed 1957; Dall 1957:154-57; Racek and Dall 1965:11; Joubert 1965:20-22 de Bruin 1965:76; Hall 1966:98; Tirmizi 1967:7.

Penaeus monodon Bate 1888:250; Kubo 1949:291-296 (part synonymy only); Menon 1956:345 (Key).

Penaeus ashiaka Kishinouye 1900:7-14; Rathbun 1902:38; Nobili 1903:2 and 1906:16.

Peneus monodon Alcock 1906:8.

Peneus semisulcatus Schmitt 1926:360&364.

Widely distributed in the tropical Indo-West-Pacific ranging from Durban Bay through Red Sea, Indian waters, Malaysia, Indonesia to northern and north eastern Australia through New Guinea, Philippine Islands to southern Japan, apparently preferring tropical habitats. On the Indian coast this is more common on the east coast. It grows to a size of 230-250 mm.

Penaeus indicus H. Milne Edwards 1837

Penaeus indicus H. Milne Edwards 1837:415; Dana 1852:604; Heller 1865: 122; Miers 1878:301; Bate 1888:248; Lanchester 1900:471; Nataraj 1942:468; Kubo 1949:311-315; Barnard 1950:588-90; Racek 1955:220-21; Menon 1956:346(Key); Hall 1956:75; 1962:16; 1966:98; Ahmed 1957; Dall 1957:162; Cheung 1960: 67-68; Racek & Dall 1965:15-16; Crosnier 1965; de Bruin 1965:76; Cheng-Ming 1965:4; Joubert 1965:24-26; Tirmizi 1967:8.

Penaeus indicus var. longirostris de Man 1892:511.

Peneus indicus Alcock 1906:12; Schmitt 1926:361.

Penaeus semisulcatus Stebbing 1915:69.

General distribution ranging from the coasts of India and Ceylon to the west through the Gulf of Aden to Madagascar and east coast of Africa, and to the east through Malaysia and Indonesia to Philippines, New Guinea and northern Australia. Due to the availability of the species

in India in all the coastal waters, estuaries and backwaters and also the large size attained, namely 200-230 mm in length, this is one of the most important commercial species here. Breeding takes place in the sea and the young ones migrate to the backwaters and estuaries, where there is a fishery for the smaller sizes upto 120-140 mm in length.

Penaeus merguiensis de Man 1888

Penaeus merguiensis de Man 1888:287-90; 1911:104-105; Kubo 1949:308-11; Racek 1955:221-22; Hall 1956:74-75; 1962:15; Dall 1957:160-62; Cheung 1960:67; de Bruin 1965:76; Racek and Dall 1965:16-17; Tirmizi 1967:8; Kirkegaard, Tuma & Walker 1967.

Penaeus indicus Bate 1888:248.

Penaeus indicus var merguiensis de Man 1892:511; Menon 1956:346 (Key).

Peneus merguiensis Schmitt 1926:360-61; Boone 1935:96-101.

Peneus indicus var. merguiensis Alcock 1906:13.

Widely distributed in tropical waters from west Pakistan eastward to New Caledonia, penetrating the Australian region southward. On the Indian coast the species contributes to a fishery only in the middle regions of both east and west coast. In other areas it is found in very small numbers. In the regions where the species contributes to a fishery juveniles are fished from estuaries. It grows to a maximum size of about 240 mm in length.

Penaeus penicillatus Alcock 1905

Peneus indicus var penicillatus Alcock 1905:525; 1906:13; Ahmed 1957

Penaeus indicus var. penicillatus Menon 1956:346 (Key).

Penaeus penicillatus Kubo 1949:306-08; Hall 1956:73-74; 1962:15; Cheung 1960:66-67; Tirmizi 1967:8.

Peneus penicillatus Schmitt 1926:361.

The distribution of the species extends from Karachi coast in West Pakistan through Malaysian waters to Taiwan. In the Indian region it is found in the fishery of the coastal waters north of Bombay. It is also recorded from Orissa coast. Grows to a maximum length of 210 mm.

Metapenaeopsis stridulans (Alcock 1905)

Metapeneus stridulans Alcock 1905:526; 1906:27-29 (not synonymy, nor figure 14b plate 5).

Metapenaeopsis stridulans Nataraj 1942:468; Hall 1961:105-09; 1962:32; 1966:99; de Bruin 1965:84-85; Racek & Dall 1965:32-34.

Metapenaeopsis novae-guineae Kunju 1960:83.

General distribution in Indian Seas and Ceylon through Malaysian waters to eastern New Guinea. In Indian waters it is found in the Bombay region as well as the northern region of east coast. The species is noticed to be represented in the "dol" net catches of Bombay in fairly large numbers particularly in the months October and November. Recorded from 5 to 30 fathoms depth. Maximum size attained is about 100 mm in length.

Metapenaeopsis mogiensis (Rathbun 1902)

Parapenaeus mogiensis Rathbun 1902:39.

Metapeneus mogiensis Alcock 1906:29-30.

Penaeopsis mogiensis Schmitt 1926:346-48.

Metapenaeopsis mogiensis Nataraj 1942:468; Dall 1957:172-74 (part synonymy); Cheung 1960:63; Racek & Dall 1965:42-44 (part synonymy only); de Bruin 1965:84.

The species has a distribution from Indian waters to South China Sea and Japan in the north east and tropical Queensland in the south east. In the Indian region it is found off the Malabar coast, Ceylon and Andaman Islands. Maximum size attained is about 90 mm in length.

Metapenaeopsis andamanensis (Wood-Mason 1891)

Metapenaeus philippinensis var. andamanensis Wood-Mason 1891:271; Wood-Mason & Alcock 1891:186-202.

Penaeus (Metapenaeus) coniger var. andamanensis Alcock 1901:17.

Metapeneus coniger var. andamanensis Alcock 1906:27.

Penaeopsis coniger var. andamanensis de Man 1911:61-62.

Metapenaeopsis coniger Kubo 1949:432-34.

Metapenaeopsis andamanensis Hall 1961:109-110; 1962:35-36; 1966:99; Racek & Dall 1965:20 (in Key); George 1967:343.

Distributed from the Indian Seas through Malaysian waters to Kei Islands and Japan. In Indian Seas it is found in the deeper waters off the south west coast and also in the Andaman Sea. Recent exploratory cruises of the Indo-Norwegian Project vessels off the south west coast of India in waters of depth from 150 to 200 fathoms have caught the species in fairly good numbers in trawl net operations suggesting commercial possibilities of exploitation of the species. Grows to maximum length of 135 mm.

Metapenaeopsis philippii (Bate 1881)

Penaeus philippinensis Bate 1881:181; 1888:261.

Penaeopsis philippii Calman 1923: 536; 1925:12; Ramadan 1938:70; Barnard 1950:592-93; John & Kurien 1959:156-59.

Metapenaeopsis philippii Dall 1957:168 (in Key); Racek and Dall 1965:20 (in Key); Hall 1966:99.

General distribution from Zanzibar through Indian Seas to Philippine Islands. This is also a deepwater form found in the catches of the recent deepwater trawling operations off south west coast of India. John & Kurien (1959) caught the species from the area and pointed out the possibility of commercial exploitation. Maximum size is about 130 mm.

Parapenaeus longipes Alcock 1905

Parapeneus longipes Alcock 1905:525; 1906:33.

Parapenaeus longipes de Man 1911:81-82; Kubo 1951:259-263; Cheung 1960: 65; Racek & Dall 1965:52-53; de Bruin 1965:99-100; George 1967:341-42.

The species has a general distribution from east Africa through Indian and Indonesian waters to New Guinea and Japan. It is recorded in Indian waters along the south west coast off Mangalore and Cochin and on the east coast off Ganjam coast, Vizagapatnam and off the mouth of river Hooghly. Maximum size about 80 mm.

Parapenaeus fissurus (Bate 1888)

Penaeus fissurus Bate 1888:263-66.

Parapeneus fissurus Alcock 1905:520; 1906:31-32.

Parapenaeus fissurus de Man 1911:79-80; 1922:9; Balss 1914:10-11; 1925:44; Stebbing 1914:19-20; Ramadan 1938:73; Kubo 1949:400-403; Barnard 1950:601-02; Dall 1957:179 (Key); Cheung 1960:65; Hall 1961:104; 1962:30; 1966:99; Racek & Dall 1965:53-54.

The distribution is very similar to that of P. longipes, extending from East Africa through Indian Seas, Malaysia and Indonesian waters to Philippines, South China Sea and Japan. In India it is recorded only from the east coast off Ganjam and also from the Andamans. Females attain a maximum length of 120 mm.

Parapenaeus investigatoris Alcock & Anderson 1899

Parapeneus investigatoris Alcock & Anderson 1899:279; Alcock 1906:32.

Peneus (Parapeneus) investigatoris Alcock 1901:18.

Parapenaeus investigatoris de Man 1911:80; Ramadan 1938:73; Kubo 1949: 406-408; Barnard 1947:382; 1950:602-04; Dall 1957:179 (Key); Hall 1966:99; George 1967:341.

Distributed from East Africa through Indian waters and Indonesian waters to Japan. In Indian waters the species is mostly recorded from Gulf of Mannar and off Pulicat Lake on the east coast and also from the Andaman Sea. It has been recently obtained from the Arabian Sea off Cochin in the deep water trawling operations. Maximum size attained about 80 mm in females.

Penaeopsis rectacuta (Bate 1888)

Penaeus rectacutus Bate 1888:266.

Metapenaeus rectacutus Wood-Mason 1891:274; Alcock & Anderson 1894:145.

Peneus (Parapeneus) rectacutus Alcock 1901:17.

Parapeneus rectacutus Alcock 1906:33.

Parapenaeus rectacutus de Man 1911: 82-83; Balss 1925:228; Yokoya 1933:9.

Penaeopsis (Penaeopsis) rectacutus Burkenroad 1934:5, 8 & 13.

Penaeopsis rectactus Kubo 1949:322-26.

Penaeopsis rectacutus Ramadan 1938:67-68; Kurien 1964:216.

Penaeopsis rectacuta Hall 1962:18; George 1967:342.

Distributed from Gulf of Aden through Indian and Malaysian waters to Philippine Islands, South China Sea and Japan. On the Indian coasts it has been recorded in smaller numbers off Madras and also in Andaman

Islands. Recent exploratory trawling operations in deeper waters of 150 to 200 fathom depths off Kerala coast has caught this prawn in appreciable quantities indicating possibility of commercial exploitation. Maximum size reached by females is 130 mm in length.

Metapenaeus lysianassa (de Man 1888)

Penaeus lysianassa de Man 1888:290-95.

Metapeneus lysianassa Alcock 1906:23-24.

Metapenaeus lysianassa Burkenroad 1934:36; Kubo 1949:359-61; Hall 1956: 82-83; 1962:24; Ahmed 1957; Dall 1957:183 (Key); Racek and Dall 1965:79-80; de Bruin 1965:81.

The species has a general distribution from Indian waters and Ceylon to North Borneo. The Indian records are mostly from the east coast, off River Hooghly, Orissa coast and Gulf of Mannar. On the west coast it is rarely found on the south west region. Females reach maximum of 90 mm length.

Metapenaeus brevicornis (H. Milne Edwards, 1837)

Penaeus brevicornis H. Milne Edwards 1837:417; Bate 1881:180; Handerson 1893:450; de Man 1897:681; Lanchester 1901:571.

Metapeneus brevicornis Alcock 1906:22-23.

Penaeopsis brevicornis Kemp 1918:294-295.

Metapenaeus brevicornis Burkenroad 1934:33-36; Kubo 1949:351-55; Hall 1956:81; 1962:24-25; Menon 1956:346 (Key); Ahmed 1957; Dall 1957:184 (Key); Racek & Dall 1965: 81-82; George 1967 (in press).

?Penaeus avirostris Dana 1852:603; Heller 1865:123; Miers 1880:457.

Penaeopsis avirostris Balss 1914:10.

Metapenaeus avirostris Nobili 1903:2.

Penaeus sp. Lanchester 1901:571-72.

General distribution of the species is West Pakistan through Indian, Malaysian Thai and Indonesian waters to about East Borneo. In the distribution of the species in Indian waters the peculiarity noticed is that unlike other allied species this does not occur in the southern areas while contributing to good fishery in the norther n region both on the west as well as east coasts. In these areas it is represented well in the estuaries also, juveniles contributing to a fishery there. Maximum size attained is up to 125 mm.

Metapenaeus dobsoni (Miers 1878)

Penaeus dobsoni Miers 1878:302.

Metapenaeus dobsoni Nobili 1903:3; Nataraj 1942:468; Menon 1956:346 (Key); Dall 1957:183 (Key); Hall 1962:25; Racek & Dall 1965: 80-81; De Bruin 1965:80; George 1967 (in press).

Metapeneus dobsoni Alcock 1906:21-22.

Penaeopsis sp. de Man 1911:60-61.

Penaeopsis dobsoni Kemp 1915:322; Panikkar 1937:345.

Distribution is Indian waters through Malaysia and Indonesia to Philippine Islands. The species is both marine and brackishwater form. This is one of the most important commercially exploited species in Indian waters. It is more common along the south west coast where it contributed to a major fishery. The adults are fished from the inshore areas up to about 40 m depth and the juveniles are fi hed from most of the estuaries and backwaters where it enters at late larval and postlarval stages after hatching out in the sea.

The species rarely exceeds 125 mm in length. The maximum size attained in the estuarine environment is 70 to 75 mm.

Metapenaeus stebbingi (Nobili 1904)

Metapenaeus stebbingi Nobili 1904:229; 1906:15; Burkenroad 1934:33; Barnard 1947:382; Barnard 1950:599-600; Tirmizi 1962:103-106; 1967:9; Ramamurthy 1964:170; Racek & Dall 1965:57 (Key); Joubert 1965:27; Hall 1966:99.

Penaeopsis stebbingi Tattersall 1921:365; Monod 1930:140.

The distribution is apparently restricted to eastern Indian Ocean region, from western South Africa through Suez, Red Sea to West Pakistan and north west coast of India. From India it is only recently recorded from the Gulf of Kutch region. Maximum size up to 120 mm length.

Metapenaeus ensis (de Haan 1850)

Penaeus monoceros ensis de Haan 1850:192.

Penaeus monoceros Haswell 1882:200.

Penaeus mastersii Haswell 1879:42; 1882:203.

Penaeus incisipes Bate 1888:257-58 (not including female); Kishinouye 1900:18-19; Blanco and Arriola 1937:223.

Penaeopsis monoceros de Man 1911:55-57; Schmitt 1926:325-29 (including part of "Penaeus mastersii").

Metapeneus incisipes Alcock 1906:51.

Metapeneus ensis Alcock 1906:24-25.

Metapenaeus monoceros Kubo 1949:329-33 (part synonymy only); Hall 1956: 77-78 (not including Fig.11); Dall 1957:184-87 (part synonymy only).

Metapenaeus incisipes Racek 1955:230-32; 1959:10.

Metapenaeus ensis Hall 1958:537-44; 1962:22-23; Racek and Dall 1965:58-61; de Bruin 1965:80; Muthu 1965:465; Cheung 1960: 66-68.

(Non Metapenaeus mastersii Racek 1955, 1957, 1959; Dall 1956, 1957, 1958 and Hall 1962).

Distribution from Indian waters through Malacca strait and Indonesian waters to New Guinea, ranging north along South East China to Japan and South to western Australia, Queensland and New South Wales. Hall (1962) considered Malacca Strait as the western boundary for the distribution of this species. But recently it has been recorded from the Bay of Bengal (Muthu 1965) as well as Ceylon waters (de Bruin 1965). In Indian waters so far it is recorded only from the east coast off Waltair and slightly south.

Maximum size attained is about 170 mm in length.

Metapenaeus monoceros (Fabricius 1798)

Penaeus monoceros Fabricius 1798:409; Milne Edwards 1837:415; Dana 1852: 605; Stimpson 1860:44 (part) Miers 1878:301; Bate 1881: 177; Ortmann 1890:450 (part); Thalwitz 1890-91:2; de Man 1892:513; 1898:680; Doflein 1902:631.

Metapeneus monoceros Alcock 1906:18-20.

Penaeopsis monoceros Kemp 1915:321; Calman 1925:12; Monod 1930:140; Panikkar 1937.

Penaeopsis spinulicauda Stebbing 1914:17; 1917:444.

Metapenaeus monoceros Nobili 1903:3; Burkenroad 1934:32-33; Nataraj 1942: 468; Barnard 1950:597-99; Menon 1956:346 (key); Ahmed 1957:9; Hall 1958:543; Racek and Dall 1965: 57 (in Key); de Bruin 1965:79-80; Joubert 1965:27-29; Hall 1966:98; George 1967 (in press).

General distribution of the species is South Africa through Mediterranean and Indian Seas to Malaysia. According to Hall (1962) its eastern limit of distribution is Malacca Strait. It is one of the

hardiest prawns and used in several physiological experiments in the Indian region. It occurs along the entire coastline, found in juvenile stages in the estuaries and backwaters and adults in the sea up to 50-60 m depths. Larger sizes are mostly caught only from deeper areas. Females attain a maximum size of 180 mm in length.

Metapenaeus alcocki George & Rao 1966.

Metapenaeus alcocki George and Rao 1966:146-151.

This is a species which has been recently described for the first time from the Gulf of Kutch area and it has not been obtained later out of the type locality. Maximum length of specimens obtained from the type locality is 97 mm.

Metapenaeus kutchensis George, George & Rao

Metapenaeus kutchesis George, George & Rao 1963: 284-288.

A species which is recorded from Indian waters only so far. It was described recently from the Gulf of Kutch area where it is found to contribute to a fishery. Maximum size attained so far is about 130 or 140 mm in length.

Metapenaeus affinis (H. Milne Edwards, 1837)

Penaeus affinis H. Milne Edwards 1837:416.

Metapeneus affinis Alcock 1906:20-21.

Penaeopsis affinis Kemp 1915:321; de Man 1924:4-5 (non 1911); Panikkar 1937:345.

Metapenaeus affinis Burkenroad 1934:29-32; Kubo 1954:82-92 (non 1949); Menon 1956:346 (Key); Dall 1957:183 (Key); Cheung 1960:66; Racek and Dall 1965:68-69; Tirmizi 1967:11; George 1967 (in press).

Penaeus mutatus Lanchester 1901:572-73.

Metapenaeus necopinans Hall 1956:82-84.

Metapenaeus mutatus Hall 1961:86-87; 1962:25; de Bruin 1965:76-78.

General distribution of the species is Indian Seas through Malaysia and part of Indonesia to Hongkong and Japan. This is a medium size prawn commercially very important along the coasts of India. Unlike the other

commercially important species of the genus the juveniles of the species are fished in small numbers only from backwaters and estuaries, the major fishery being from the inshore waters up to 45 to 50 m depths.

Meximum length attained is about 180 mm.

Metapenaeus burkenroadi Kubo 1954

Metapenaeus burkenroadi Kubo 1954:92-93; Dall 1957:183 (Key); Racek 1957: 6-7; Cheung 1960:66,68; George 1964:313-14; Racek & Dall 1965:72-73; de Bruin 1965:78-79.

Penaeus affinis Kishinouye 1900:16-18.

Penaeopsis affinis Balss 1914:7; 1924:44 (non de Man 1911).

Parapenaeus affinis Rathbun 1902:38.

Metapenaeus affinis Nataraj 1942:468; Kubo 1949:340-44 (part synonymy only).

Metapenaeus mastersii Hall 1962:23-24 (non Racek 1955, 1957, 1959; Dall 1957, 1958).

Distributed chiefly in waters north of equator ranging from Japan through Hong Kong seas and Malaysia to southern India and Ceylon. From India it was only recently recorded in the inshore waters as well as estuary in Cochin.

Maximum size reached is about 100 mm.

Atypopenaeus stenodactylus (Stimpson 1860)

Penaeus stenodactylus Stimpson 1860:431.

Penaeus compressipes Henderson 1893:450-51.

Atypopeneus compressipes Alcock 1906:45-46.

Atypopenaeus compressipes de Man 1911:83-84; Kubo 1949:366-68; Dall 1957: 199 (Key); Kunju 1960:82-83; Racek & Dall 1965:84-85.

Parapenaeopsis brevirostris Kubo 1936:55-58.

Atypopeneus stenodactylus Hall 1961:87-88; 1962:25-26; de Bruin 1965:94.

General distribution from Indian Seas through Malaysian and Hong Kong waters to Japan. This is a small penaeid prawn recorded from both the coasts in India, off Madras in the east coast in very small number and in Bombay waters in the west coast where it contributes to a fishery. In the 'dol' nets (fixed bag nets) operated at 6 to 15 fathom depths in Bombay waters these prawns are caught in large numbers throughout the

year according to Kunju (1960).

Maximum size reached is only 50 mm in length.

Trachypenaeus pescadoreensis Schmitt 1931

Trachypeneus pescadoreensis Schmitt 1931: 265-68; Hall 1961:29.
Trachypeneus granulosus Hall 1961:100.
Trachypeneus furcilla Hall 1961:102-04.

Distribution south west and south east coast of India, eastern Malaya and Northern Australia. From Indian waters it is only recently obtained in collection from south east coast (under publication) and 1 male specimen from south west coast off Trivandrum. This is the first report of the species from this region. Although the specimens obtained from the coast of India so far are smaller the species attains a maximum size of 90 mm.

Trachypenaeus sedili Hall 1961

Trachypeneus sedili Hall 1961:100-102; 1962:30; de Bruin 1965:92-93.
Trachypenaeus sedili Muthu (in press).

Since Hall (1962) described the species from Malayan waters, de Bruin (1965) recorded it from Ceylon extending its distribution eastwards in the Indian Ocean. Recently in the collection from Visakhapatnam coast in the Bay of Bengal it was obtained (Muthu, press). Maximum size about 60 mm in length.

Trachypenaeus curvirostris (Stimpson 1860)

Penaeus curvirostris Stimpson 1860:44; Kishinouyé 1900:23.
Penaeus granulosus Miers 1884:295.
Parapenaeus curvirostris Rathbun 1902:38.
Trachypeneus asper Alcock 1905:531; 1906:43; Cheng-Ming 1965:14.
Trachypenaeus anchoralis de Man 1911:88-90.
Trachypeneus curvirostris Alcock 1905:823; Schmitt 1926:353-58; Hall 1961: 98-100; 1962:29; 1966:99; de Bruin 1965:92.
Trachypenaeus (Trachysalambria) curvirostris Racek 1955:235-56 (except Fig.4 plate 7); 1959:10.

Trachypenaeus curvirostris Balss 1914:11; 1924:44; Ramadan 1938:63; Kubo 1949:393-95; Liu 1955:14-16; Dall 1957:203-06; Cheung 1960:65 (Key); Kunju 1960:83; Racek and Dall 1965:89; Cheng-Ming 1965:13; George 1967: 343-44.

This species has a general distribution from eastern Africa through Indian, Ceylon and Malaysian waters to Japan and Australia occurring in depths from 10 to 30 fathoms. In Indian waters it is found both in the east as well as west coasts, but not in very large numbers as to contribute to a fishery. Maximum size is about 95 mm.

Parapenaeopsis uncta (Alcock 1905)

Parapeneopsis uncta Alcock 1905:528; 1906:39; de Bruin 1965:96-98.

Parapenaeopsis uncta Nataraj 1942:468; Menon 1956:346 (Key); Ahmed 1957; Dall 1957: 214 (Key).

Parapeneopsis probata Hall 1961:96; 1962:27.

This is a species having apparently limited distribution in Indo-Pacific, being found only in Indian, Ceylon and Malayan waters. In India it is recorded from Orissa coast as well as south west coast. Maximum size reached by females is 100 mm in total length.

Parapenaeopsis stylifera (H. Milne Edwards 1837)

Penaeus styliferus H. Milne Edwards 1837:418.

Penaeopsis styliferus Bate 1881:183.

Parapenaeopsis styliferus Nobili 1903:4.

Parapeneopsis stylifera Alcock 1906:36-37.

Parapeneopsis stylifera var. coromandelica Alcock 1906:37; Menon 1956:346 (Key).

Parapenaeopsis stylifera de Man 1911:9; Nataraj 1942:468; Menon 1956:346 (Key); Ahmed 1957:12; Dall 1957:214(Key); Rao 1967; Tirmizi 1967:13; 1968:193-203.

Parapeneopsis coromandelica Hall 1962:27; de Bruin 1965: 99.

Parapenaeopsis stylifera coromandelica Racek & Dall 1965: 96-98.

Parapenaeopsis stylifera stylifera Racek & Dall 1965: 98.

Distributed from Indian and Ceylon waters through Malaysian waters to Indonesia and Borneo. In Indian waters it is distributed all along the coastline, more especially on the west coast and south east coast.

Along the entire west coast this is one of the most important commercially exploited species. Unlike the other coexisting commercially exploited species this has no estuarine phase in its life history, the larvae or post-larvae never entering the backwaters and estuaries.

Maximum size reached by females is about 140 mm in length.

Parapenaeopsis cornuta maxillipedo Alcock 1906

Parapeneopsis maxillipedo Alcock 1906:40-41; Hall 1961:89-90; 1962:26; de Bruin 1965: 94-95.

Parapenaeopsis maxillipedo Nataraj 1942:468; Kubo 1949:380-81; Menon 1956:346 (Key); Dall 1957:217.

Parapenaeopsis cornutus Cheung 1960:65 (Key); Cheng-Ming 1965:15.

Parapenaeopsis cornuta maxillipedo Racek & Dall 1965:99.

This has an equatorial spread from the west coast of India and Ceylon through Malaysia to the Philippines and New Guinea. In Indian waters although not contributing to a fishery it has been recorded from Bombay and Kerala on the west coast and off Madras on the east coast.

Maximum size attained is 125 mm in length.

Parapenaeopsis nana (Alcock 1905)

Parapenaeopsis nana Alcock 1905:529; 1906:41-42; de Bruin 1965:99.

Parapenaeopsis nana Dall 1957:214 (Key).

Apparently the distribution of this species is restricted to Indian and Ceylon waters. Even in Indian waters it has been recorded only from the east coast, off Orissa coast and Madras. It is a small species with females recorded up to 55 mm in length.

Parapenaeopsis sculptilis (Heller 1862)

Penaeus sculptilis Heller 1862:528; 1865:122; Miers 1880:457.

Parapenaeopsis sculptilis Nobili 1903:5; Balss 1914:11; Boone 1935:80-84; Kubo 1949:389-91; Menon 1956:346 (Key); Ahmed 1957; Dall 1957:217-20; Rajyalakshmi 1962:53,55, 56; Racek & Dall 1965:100; Tirmizi 1967:13; Kirkegaard & Walker 1967.

Parapeneopsis sculptilis Burkenroad 1934: 59-60; Racek 1959:10, 12, 14.

Peneopsis (printing error) sculptilis Alcock 1906:37-38.

Parapeneopsis affinis Hall 1961:93-94; 1962:27.

General distribution from west coast of India through Malaysian waters and Indonesia to Hong Kong in the north and tropical Australia and New Guinea in the south. Along the Indian coasts this is mostly represented in the northern region of the west coast and the east coast. In these places the species contribute to the fishery to a certain extent.

Maximum size attained is about 165 mm in length.

Parapenaeopsis hardwickii (Miers, 1878)

Penaeus hardwickii Miers 1878:300.

Parapeneopsis sculptilis var. hardwickii Alcock 1906:39.

Parapeneopsis sculptilis var. cultrirostris Alcock 1906:39.

Parapeneopsis hardwickii Burkenroad 1934:60-64; Hall 1961:93; 1962:26-27.

Parapenaeopsis cultrirostris Kubo 1949:378-80 (not figure 137).

Parapenaeopsis hardwickii Kubo 1949:385-89 (not figure 140); Dall 1957: 214 (Key); Cheung 1960:65 (Key); Kunju 1969:82; Racek & Dall 1965:101-102, Tirmizi 1968:137-40.

Distribution from Indian waters through Malaysia to southern China. In Indian waters the species is distributed in the north west coast in Bombay waters and on the east coast mainly off river Godavari estuary. In these two places it contributes to a fairly good fishery, especially in Bombay waters. Attains a maximum size of about 120 mm in length.

Parapenaeopsis tenella (Bate, 1888)

Penaeus tenellus Bate 1888:270-71; Kishinouye 1900:22.

Penaeus crucifer Ortmann 1890:451.

Penaeus (Parapenaeopsis) tenellus de Man 1907: 435-36, 454.

Parapenaeopsis tenella de Man 1911:9, 92; Balss 1914:11; Yoshida 1941:15-16; Racek & Dall 1965:108-09; Thomas (in press).

Parapenaeopsis tenellus Kubo 1949:371-74; Liu 1955; 16-17; Dall 1957:221-223; Cheung 1960:65.

Parapeneopsis tenella Hall 1961:89; 1962:26; de Bruin 1965: 98-99.

Para[illegible])

Distributed from east coast of India and Ceylon through Malaysia to Northern China, Southern Japan and Northern Australia. From Indian waters it has only recently been collected from the east coast from Palk Bay and Gulf of Mannar (Thomas, press) in very small numbers. This is a small prawn growing to a maximum of only about 50 mm in length.

Parapenaeopsis acclivirostris (Alcock 1905)

Parapeneopsis acclivirostris Alcock 1905:530; 1906:42-43.
Parapenaeopsis acclivirostris Barnard 1947:382; 1950:604-605; Dall 1957: 215 (Key); Kunju 1960:83; Hall 1966:99.

This species is very closely allied to P. tenella and this has so far been only reported from South Africa, the Persian Gulf ~~of~~ and Indian Seas, both east and west coasts. The original record of the species from the east coast by Alcock was based on a collection of only females. ~~Recently~~ Kunju (1960) recorded males also from Bombay waters where it is found in small numbers along with other commercial species. This is also a very small prawn reaching a maximum size of about 50 mm in length.

Family Palaemonidae

The Palaemonids are mostly freshwater prawns, sometimes occupying the coastal and brackish waters also. Those coastal species which are found in brackishwaters and which are of some commercial significance are dealt with below:

Palaemon (Nematopalaemon) tenuipes (Henderson 1893)

Leander tenuipes Henderson 1893:440; Nobili 1903:7; Kemp 1917:206; 1917a: 234; 1925:289; Chopra 1943:5; Rajyalakshmi 1962:53,58,59.
?Leander off. tenuipes Vatova 1943:11.
Palaemon (Nematopalaemon) tenuipes Holthuis 1950:44-45; Ganapati & Subrahmanyam 1966:13; Kunju 1967:1385.

The species occurs in superficial coastal waters upto a depth of about 20 m as well as in estuarine and brackishwaters. It has a general distribution from Indian waters through Malaysia to New Zealand. In Indian region it is found to occur mostly in the northern areas of both the east and west coasts where it contributes to good fishery. In the coastal

waters of Bombay as well as in the Gangetic delta area the species is one of the most important commercial prawns.

Attains a maximum size of only 80 mm in total length.

Palaemon (Exopalaemon) styliferus H. Milne Edwards 1837

Palemon longirostris H. Milne Edwards 1837:394.

Palemon styliferus H. Milne Edwards 1840:638.

Leander longirostris Henderson 1893:439; Nobili 1901:3; 1903:7.

Palaemon styliferus Rathbun 1902:51; Suvatti 1937:50.

Leander sp. de Man 1908:220.

Leander styliferus Kemp 1915:273; 1917:124; 1917a:234; 1925:289: Balss 1930:316; Rai 1933:886; Panikkar 1937:345; Chopra 1939:223; 1943:5; Ahmed 1957; Kunju 1956:1-15; Rajyalakshmi 1962:53, 58.

Palaemon (Exopalaemon) styliferus Holthuis 1950:46-48; Ganapati & Subrahmanyam 1966: 13; Kunju 1967:1385.

It is distributed in shallow coastal waters and brackish water areas. In some areas it has even been recorded from fresh water. General distribution is apparently restricted to West Pakistan and Indian waters to Malay Archipelago. Along the coasts of India as in the case of P. tenuipes this species is also more common in the northern regions of both the coasts. In the Gangetic delta area this is one of the most important commercial species.

It attains a maximum size of about 90 mm in length and spawning is known to occur in the more saline areas.

Macrobrachium rosenbergii (de Man) 1879

Palaemon rosenbergii de Man 1879:167.

Palaemon carcinus Fabricius 1798:402; de Man 1879:165; Rai 1933:886; Panikkar 1937:345; Patwardhan 1937:1-100; Menon 1938:290; Chopra 1939:222; 1943:71; Nataraj 1942:468; Tiwari 1955: 231-232; Ahmed 1957; John 1957:93-102; Rajyalakshmi 1961:1962:53.

Macrobrachium rosenbergii Holthuis 1950:111-119 (with complete synonymy); Ling 1961:55-60; 1962:1-11; Raman 1964:21-23; 1967:649-669; Bhimachar 1965:1,4,6; Rao 1965: 19-25; 1967:252-79; Ganapati & Subrahmanyam 1966:13; Kunju 1967:1385; Jones 1967:1336,37; 1967:9-11.

This is the giant freshwater prawn often occurring in brackish water environments like lakes and estuaries. The western most limit of its distribution is Indus delta area. It is most widely distributed in the Indo-Pacific zone, extending only up to Indo-China in the Asian mainland. It is common in most of the lakes and estuaries along the coastline of India. Breeding takes place in the gradient zones of the estuaries, the adults migrating to these zones during the breeding period. The young post-larvae ascend to the upper reaches of the rivers. During the monsoon and post-monsoon months the species is fished extensively from the backwater systems of Kerala and contributes to a very good freezing industry.

Grows to a maximum length of 300 to 320 mm, males showing the maximum size.

Macrobrachium villosimanus Tiwari 1947

Palaemon villosimanus Tiwari 1947:329-30; 1955:231-232.

This is a species with very limited distribution. Outside the type locality of Calcutta, Bengal it has been obtained from Chittagong and Rangoon. Maximum size about 150 mm in body length.

Macrobrachium lamarrei (H. Milne Edwards 1837)

Palemon lamarrei H. Milne Edwards 1837:397.

Palaemon lamarrei de Man 1897:767; Henderson & Mathai 1910:301; Kemp 1915: 265; Balss 1930:318; Hora 1933:4, 5; Sewell 1934:53,55, 58; Nath 1937:149; Chopra 1939:223; Chopra and Tiwari 1949:214; Tiwari 1955:234; Ahmed 1957.

Palaemon (Eupalaemon) lamarrei de Man 1908:222.

Macrobrachium lamarrei Holthuis 1950:119-21 (with complete synonymy); Ganapati & Subrahmanyam 1966:13.

The species occurs in fresh and brackishwaters and it is confined to India and Pakistan. In India it is mostly occurring in the northern region of the east coast from Chilka lake and Bengal.

Macrobrachium malcolmsonii (H. Milne Edwards 1844)

Palaemon malcolmsonii H. Milne Edwards 1844:8.

Palaemon spinipes birmandicus Schenkel 1902:503.

Palaemon malcolmsonii Henderson & Mathai 1910:283; Kemp 1915:266; Balss 1930:318; Patwardhan1937:1; Chopra 1939;223; 1943:5; Chopra and Tiwari 1949:214; Tiwari 1955:231,232; Ahmed 1957; Rajyalakshmi 1962.

Macrobrachium malcolmsonii Holthuis 1950:121-23; Ibrahim 1962:433-67; Bhimachar 1965:1; Ganapati and Subrahmanyam 1966:13; Jones 1967:11; 1967:1336, 37.

The species inhabits fresh and brackishwaters, having a general distribution in India and Burma. It is most common in peninsular rivers that drain into the Bay of Bengal. On the western side it is known to occur in river Indus. In the northern part of the east coast this species contributes to a fairly good fishery during the monsoon months. Migration to brackishwaters during the breeding season is common in this species also.

Females attain a maximum size of about 180 to 200 mm while males reach a slightly higher length up to 230 mm.

Macrobrachium rude (Heller 1862)

Palaemon rudis Heller 1862:527; 1865:114; Henderson & Mathai 1910:291; Kemp 1915:268; Balss 1930:318; Sewell 1934:35; Menon 1938:288; Chopra 1939:223; 1943:4; Tiwari 1955:231,232; Ahmed 1957.

Palaemon (Eupalaemon) rudis Nobili 1903:11; Vatova 1943:13; Barnard 1950:778-779.

Macrobrachium rude Holthuis 1950:150-51 (with complete synonymy); Ganapat & Subrahmanyam 1966:13; Jones 1967:11; 1967:1336, 37 (rudis).

General distribution is East Africa and Madagascar and the Indian coasts. It is reported from Ceylon also. In India on the west coast the species is found only in the south west region. On the east coast although found throughout the regions it is most common along the deltaic Bengal , Orissa and Andhra coasts. In Bengal the species occurs from August to October. In Chilka lake area it is common from September to November.

It is comparatively a smaller species attaining a maximum length of 120-130 mm, males growing to a larger size than females.

Macrobrachium idae (Heller 1862)

Palaemon idae Heller 1862:416.

Palaemon idae Ortmann 1891:717; Estampador 1937:489; Panikkar 1937; Nataraj; 1942:468; 1947:89; Chopra 1943:5; Tiwari 1955: 231-232.

Palaemon (Eupalaemon) idae de Man 1897:767; Borradaile 1907:67.

Macrobrachium idae Holthuis 1950:142-46 (with complete synonymy); Kunju 1967:1385; Jones 1967:11; 1967:1337.

This is a fresh water species occurring also in brackishwaters. It has a general distribution from East Africa and Madagascar through Indian coasts to Java, Sumatra and Malayan Archipelago. In India its distribution is more or less similar to that of M. rude more common along the east coast. During breeding season migration to brackishwaters takes place. There are stray records from open sea.

Maximum size attained is also similar to the previous species, abut 100 to 110 mm in length.

Macrobrachium equidens (Dana 1852)

Palaemon equidens Dana 1852:26; 1852:591; de Man 1888:283; Ortmann 1891:718.

Palaemon (Eupalaemon)sundaicus de Man 1897:779; Nobili 1903:8; Roux 1932: 569; Barnard 1950:775-76.

Palaemon sundaicus Lanchester 1901:568; 1906:132; Estampador 1937:489.

Palaemon sulcatus Henderson & Mathai 1910:289; Panikkar 1937:346; Nataraj 1942:468; Tiwari 1955:231,232.

Macrobrachium sundaicus Suvatti 1937:49; Cheng Ming 1965:25.

Macrobrachium equidens Holthuis 1950:162-72 (with complete synonymy).

Palaemon sulcatus described by Henderson and Mathai (1910) has been synonymised with P. sundaicus and P. equidens by Holthuis (1950). This species has a wide distribution extending from Africa to south west New Guinea. But in Indian waters it is found only in Kerala area and in small numbers. It is found in freshwater as well as brackishwater environments.

It grows to a maximum length of about 100 mm.

Macrobrachium mirabile Kemp 1917

Palaemon mirabilis Kemp 1917:227; 1917:234; Sewell 1934:54,55; Rajyalakshmi 1961; Tiwari 1955:231,232, Ahmed 1957.

Macrobrachium mirabilis Suvatti 1937:49; Bhimachar 1965:2; Jones 1967:1337.

Macrobrachium mirabile Holthuis 1950:174; Jones 1967:11.

The species has a distribution extending from India through Burma to Malayan Archipelago and Borneo. It is an estuarine species occurring in India mostly in Gangetic delta area.

The maximum size attained by the species has been recorded to be 65 mm.

Macrobrachium javanicum (Heller 1862)

Palaemon javanicus Heller 1862:421; 1865:116; Ortmann 1891:732; Tiwari 1955:231-232.

Palaemon (Parapalaemon) javanicus de Man 1892:457; Nobili 1900:483; Roux 1932:565, 571.

Palaemon (Eupalaemon) neglectus 1905:201.

Palaemon neglectus Kemp 1918:265.

Macrobrachium neglectus Suvatti 1937:49.

Macrobrachium javanicum Holthuis 1950:190-93 (with complete synonymy).

Holthuis (1950) established the synonymy of this species with Palaemon neglectus. This is a freshwater species found in estuaries also. The general distribution is similar to that of the previous species. In India the species is restricted to deltaic Bengal.

Maximum size attained is about 100 mm in length.

Macrobrachium scabriculum (Heller 1862)

Palaemon scabriculus Heller 1862:527; 1865:117; Ortmann 1891:710; Henderson 1893:442; Henderson & Mathai 1910:296; Kemp 1915:272; Panikkar 1937:346; Tiwari 1955:231,232.

Palaemon dolichodactylus Ortmann 1891:732; Henderson & Mathai 1910:300; Colosi 1918:105; Panikkar 1937:346; Nataraj 1942: 468; Ahmed 1957: Tiwari 1955: 231,232.

Palaemon (Parapalaemon) scabriculus de Mann 1897:786; 1898:708; Nobili 1900:483; 1903:12.

Palaemon dubius Henderson & Mathai 1910:300.

Palaemon (Parapalaemon) dolichodactylus Nobili 1903:13; Calman 1913:926; Vatova 1943:12.

Macrobrachium scabriculum Holthuis 1950:224-27 (with complete synonymy); Jones 1967:1337.

This is an extremely variable species and Holthuis (1950) synomised P. dolichodactylus, P. dubius and P. scabriculus. It has got a distribution in the region around the Indian Ocean, extending from Africa, through the south-west and eastern coasts of India to Malay Archipelago. In Indian waters it occurs mostly in the deltaic Bengal, Chilka lake, south west coast in Kerala and south east India in Madras.

Maximum size attained is 100 mm in length.

Pandalidae

There are very few Pandalid prawns of any commercial significance in Indian waters. As a result of recent deep water trawling operations certain species have been obtained which are of potential commercial significance. These are dealt with below:

Parapandalus spinipes (Bate 1888)

Plesionika spinipes Bate 1888:646.

Pandalus (Parapandalus) spinipes Alcock 1901:100.

Plesionika spinipes var. grandis Doflein 1902:618.

Parapandalus spinipes var. grandis Balss 1914:31.

Parapandalus spinipes Chilton 1911:547; de Man 1920:152; Calman 1939:201-202; George & Rao 1966:330.

General distribution of the species is from Zanzibar area through Red Sea, Gulf of Aden and Arabian Sea to Malay Archipelago and New Guinea. From Indian waters it has been recorded only from the Arabian Sea off the south west coast. In the recent deep water exploratory cruises this is one of the species landed in fairly good quantities from 150 to 200 fathom depths off Kerala coast, so much so it is of potential commercial importance.

Maximum size reached by females is 130 mm in length.

Plesionika martia (A.M. Edwards 1883)

Pandalus martius A. Milne Edwards 1883:21; Rathbun 1906:914.

Pandalus (Plesionika) martius Alcock 1901:95; Lloyd 1907: 4.

Plesionika martia var. semilaevis de Man 1920:116-21 (with synonymy).

Plesionika martia Kemp 1910:30; Stebbing 1910:392; Balss 1914:30; 1925: 278; Schmitt 1926:377; Calman 1939:197; Chace 1940:190; Barnard 1950:679; George and Rao 1966:330.

This is a very widely distributed species occurring both in the Atlantic and the Pacific region. General distribution extends from Eastern Atlantic and Mediterranean through Indian Seas to Japan, Australia and Hawaiian Islands. In Indian waters it is found to occur in both the Arabian Sea and the Bay of Bengal. Alcock's locality includes Andaman Sea also. This species also has been recently obtained in good numbers in the deep water exploratory trawling in depths of 150 to 200 fathoms off Kerala.

Maximum length attained is about 125 mm. In both these Pandalids the rostrum is very long wi h the result the size of the abdomen which is the actual product of commerce will be comparatively small.

Plesionika ensis (A. Milne Edwards 1881)

Acanthephyra ensis A. Milne Edwards 1881:14.

Pandalus ensis A. Milne Edwards 1883:18; Rathbun 1906:914.

Plesionika uniproducta Spence Bate 1888:641.

Pandalus (Plesionika) ensis Alcock 1901:96.

Plesionika ensis de Man 1920:113 (Key); Holthuis 1951:55-59; Suseelan & Mohamed (under publication).

Like P. martia this species also enjoys a world-wide distribution and has been reported from Pacific, Atlantic and Indian oceans. It is recorded from Barbados, Martinique and Granada of West Indies, Barra Grande in Brazilian coast, Rio muni in Gulf of Guinea, Hawaiian Islands and Andaman Sea. It has recently been reported from the Arabian Sea, specimens obtained in the deep water trawling operations off Kerala coast.

Maximum length attained is more or less the same as the previous species.

Heterocarpus gibbosus Bate 1888

Heterocarpus gibbosus Bate 1888:634; Wood-Mason 1892:368;369; Alcock 1901:103; de Man 1920:163-164; George & Rao 1966: 331.

Distributed off Tablas Island, Indian Seas, Bali Sea and Kei Islands. In Indian Seas the species has been recorded from the Arabian Sea, Bay of Bengal and Andaman Sea. This also is one of the species obtained in the deep water trawling operations off Kerala, but not in large numbers.

Maximum size reached in 140 mm in length.

Heterocarpus woodmasoni Alcock 1901

Heterocarpus Wood-masoni Alcock 1901:108; de Man 1920:156-59; Balss 1925: 286; Calman 1939:204; George & Rao 1966:331.

This has a distribution extending from East African coast through Indian seas to Kei Islands. In Indian seas it has been recorded from Andaman Sea by Alcock and recently recorded from the Arabian Sea off Kerala coast. This is one of the dominant species obtained in the recent deep water trawl catches off Kerala. The possibility of commercial exploitation of the species is worth consideration.

Maximum size attained as shown by the recent catches is 130 mm in length.

Hippolytidae

Hippolysmata (Exhippolysmata) ensirostris Kemp 1914

Hippolysmata ensirostris Kemp 1914:118-20; 1916:403-04; de Man 1929:128; Ganapati and Subrahmanyan 1966:12; Kunju 1967: 1385; Bensam & Kartha 1967:736-743.

Exhippolysmata ensirostris Balss 1933:85.

Hippolysmata (Exhippolysmata) ensirostris Holthuis 1947: 74-75.

This species has a distribution in waters of India, Ceylon, Burma and Sumatra. Along the Indian coasts this species is present in most regions and represented in the fishery in small numbers. In Bombay and Godavary estuary ~~mouth~~ area there is fairly good fishery for the species.

Maximum length attained is about 80 mm.

Hippolysmata (Hippolysmata) **vittata** Stimpson 1860

Hippolysmata vittata Stimpson 1860:26; Lanchester 1901:563; Nobili 1906: 46; de Man 1907:423; Balss 1914:48; Kemp 1914:113; 1925:330; Borradaile 1917:403; Gravely 1927:137; Hale 1929:67; Yu 1935:51; Suvatti 1937:48; Barnard 1947:386; 1950:710-11; Pillai 1966:152-58; Kunju 1967:1385.

Nauticaris unirecedens Bate 1888:608.

Hippolysmata (Hippolysmata) vittata Holthuis 1947:67-68.

This is more widely distributed than the previous species. Its distribution extends from South Africa through Red Sea, Persian Gulf and Indian Seas to East Indies and Japan. In the matter of economic importance in India it is much less important when compared to H. ensirostris. It is represented along with the other species in small numbers.

It is a smaller species growing only to about 40 mm in length.

Sergestidae Dana

Sergestinae Bate

In the family Sergestidae only the genus Acetes is important as the commercial shrimps. 5 species belonging to this genus are of some significance commercially. Their systematics is given below:

Acetes indicus H. Milne Edwards 1830.

Acetes indicus H. Milne Edwards 1830:351; 1837:430; Dana 1852:608; Walker 1890:112; Henderson 1893:452; Pearson 1905:75; Kemp 1917: 47; Burkenroad 1934:126; Boone 1935:101-105; Odefax 1940: 342; Ganapati & Subrahmanyam 1966:12; Kunju 1967:1384; Pathansali 1966:60.

Acetes spiniger Hansen 1919:43-44.

This is commercially a very important shrimp in India. General distribution of the species is from Indian seas through Mergui Archipelago and Gulf of Siam to Malaya and East Indies. In Indian seas it is most common in Bombay waters where it contributes to a substantive percentage of the fishery. On the west it occurs only in the northern region and that in great quantities. On the east coast it is represented throughout the regions, occurring in sea as well as brackishwaters. In Bombay waters

about 20% of the total prawn fishery is contributed by this species. It is found in company with *A. japonicus* on the west coast of India and Mergui Archipelago while present in company of *A. erythraeus* along the east coast of India.

This is the largest among the different species, females reaching 40 mm in total length.

Acetes erythraeus Nobili 1905

Acetes erythraeus Nobili 1905:394; 1906:23; Kemp 1917:51-54; Menon 1933: 2-17; Burkenroad 1934:126; Colefax 1940:343; Nataraj 1942:468; 1947:142; Kow 1954:146; Pathansali 1966:60.

Acetes sp. Hansen 1919:37-38.

This species has a general distribution from Red Sea through Bay of Bengal and Gulf of Siam to Malay Archipelago. In Indian waters the species seems to be restricted to the east and south-west coasts, found in fairly good quantities in Bengal, Orissa, Madras region on the east coast and off Trivandrum, in the south west coast. Along the Trivandrum coast it occurs in large quantities from the middle of December to the middle of April.

In size it is smaller than *A. indicus*, large females attaining a maximum of only up to 30 mm in length and males only 20 mm.

Acetes sibogae Hansen 1919

Acetes sibogae Hansen 1919:38-39; Burkenroad 1934:126; Colefax 1940:343; Nataraj 1942:468; 1947:143-45; Pathansali 1966:61.

Acetes erythraeus (part) Kemp 1917:53.

Acetes australis Colefax 1940:345-53.

Compared to previous species this is of restricted distribution in Indian waters being recorded only from Quilon on the south west coast. General distribution is Bay of Bima and Java Sea, Malaya and New South Wales. Apart from the stray specimen recorded by Nataraj (1947) from Quilon there is no record of the species from other parts of India.

In size this is smaller than *A. indicus* being only 35 mm in total length in the case of largest females.

Acetes serrulatus Krøyer 1859

Sergestes serrulatus Krøyer 1859:268.

Acetes insularis Kemp 1917:54-56; Colefax 1940:343.

Acetes serrulatus Hansen 1919:41-43; Burkenroad 1934:126; Colefax 1940: 343; Kow 1954:146; Pathansali 1966:61.

General distribution of the species is in Indo-China Sea, Borneo and Singapore. The typical species is not recorded from India. But a variety of this *Acetes serrulatus* var. *johni* has been recorded from the coastal waters of Travancore by Nataraj (1947). This variety is found abundantly in the coastal waters from the middle of December to the middle of April along with *A. erythraeus.*

This is a small species reaching only to about 20 mm in length.

Acetes japonicus Kishinouye 1905

Acetes japonicus Kishinouye 1905:163; Kemp 1917:56-58; Burkenroad 1934: 127; Colefax 1940:343; Pathansali 1966:60.

Acetes dispar Hansen 1919:39-41; Colefax 1940:343; Nataraj 1942:468; 1947:145-46.

The known distribution of the species may be summarised as west and south coasts of India, lower parts of Bay of Bengal, Gulf of Siam, Java, Korea and Japan. In Indian waters it occur along with *A. indicus* and *A. erythraeus* in small numbers. Off Trivandrum coast this species occur in large number only in July.

Large specimens reach a length of about 26 mm.

Acetes cochinensis Rao

Acetes cochinensis Rao (in press)

This is a new species of *Acetes* recorded and described very recently from the collections of Cochin waters. It occurs in the plankton of both the sea and the backwater and in larger numbers in May, June.

Maximum size attained is 20 mm in length.

III GENUS *PENAEUS* FABRICIUS 1798

By

K.H. Mohamed

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III GENUS PENAEUS FABRICIUS 1798

K.H. Mohamed

The Genus Penaeus has a world wide distribution and the various species belonging to it are found both in tropical and temporate latitudes. Practically all of them are marine although some are known to spend a part of their life in the brackish water and even in fresh water. Of the 28 valid species of the genus only 8 are represented in Indian waters, they being *Penaeus japonicus* Bate, *P. latisulcatus* Kishinouye, *P. canaliculatus* (Olivier), *P. monodon* Fabricius, *P. semisulcatus* de Haan, *P. indicus* H. Milne-Edwards, *P. merguiensis* de man and *P. penicillatus* Alcock.

Most of the species belonging to this genus grow to large sizes and they support commercial fisheries in many parts of the world, accounting for over 50% of the total world production of prawns and shrimps. All the 8 species recorded from India are listed (Holthuis and Rosa, 1965) as prawns of economic value although some of them do not occur in commercial quantities in India.

1. PENAEUS INDICUS H. MILNE-EDWARDS, 1837

The distinguishing characteristics of the species (Fig. 3) are as follows:

Body completely glabrous. Rostrum slender, long with distinct double curve, 1½ to 2 times in length of carapace in the juvenile stages, first five dorsal teeth close together, penultimate and distal teeth widely separated, position of latter variable. Rostrum becomes shorter with increasing size, equalling length of carapace in prawns of 80 mm, almost straight and with higher blade. Rostrum extending beyond tip of antennular scale in large prawns, blade high but not forming a triangular crest. Adrostral groove shallow, decreasing in depth backwards up to epigastric tooth. Eight to nine (sometimes seven) dorsal and four to

five ventral teeth on rostrum. Carapace glabrous, thin, sulci and carina feebly defined. Gastro-orbital carina occupying the posterior 2/3 distance between hepatic spine and orbital angle. Orbitoantennal sulcus wide and ill-defined. Postantennular spine continued as an oblique ridge to the hepatic spine. Subhepatic ridge absent. Abdominal segments four to five keeled, keel on sixth segment ending acutely. Telson grooved, without lateral spines. Second and third joints of the first leg and second joint of the second leg provided with a spine.

Maxilliped III reaches to the second segment of the antennular peduncle. Dactyle of maxilliped III of adult male as long as the propodus. First, fourth and fifth pereopods reach the first segment of the antennular peduncle; the second limb extending to tip of antennular peduncle and third surpassing the same by half length of chela. Mandibular palp two segmented, last segment subrhombiodal, bluntly pointed at the apex, nearly twice as long as wide. Endopodite of maxillula segmented in two. Distal piece of appendix masculina deltoid in outline with rounded apex fringed with thickly set setae. Sixth abdominal somite as long as telson.

Median lobe of petasma rounded at tip, projecting forward up to the apex of the lateral lobe which is covered with sparsely set fine setae on outer surface. Terminal portion of the distal margin serrated with 12 well-calcified teeth. Anterior median process of thelycum roughly semicircular and relatively small situated on sternite between fourth pereopods. There are minute apical spines on the anterior margin of this process. The two large lateral plates housing seminal receptacles occupy most part of the last thoracic sternite. The lateral plates meet each other in the median line where the edges of the plates are up-curved to form an appearance of a valve (Fig. 3)

Cardiac plate has 21 to 23 equidistant spinules set on a longitudinal row. Zygocardiac ossicle has 8 to 13 conical teeth set in an arc-shaped series. Prepyloric armed with about 10 pointed teeth which get successively larger towards tip. Hall (1962) has shown that variations in the number of spinules in the different components of the stomodial apparatus are more or less similar in _P. indicus_ and _P. merguiensis_.

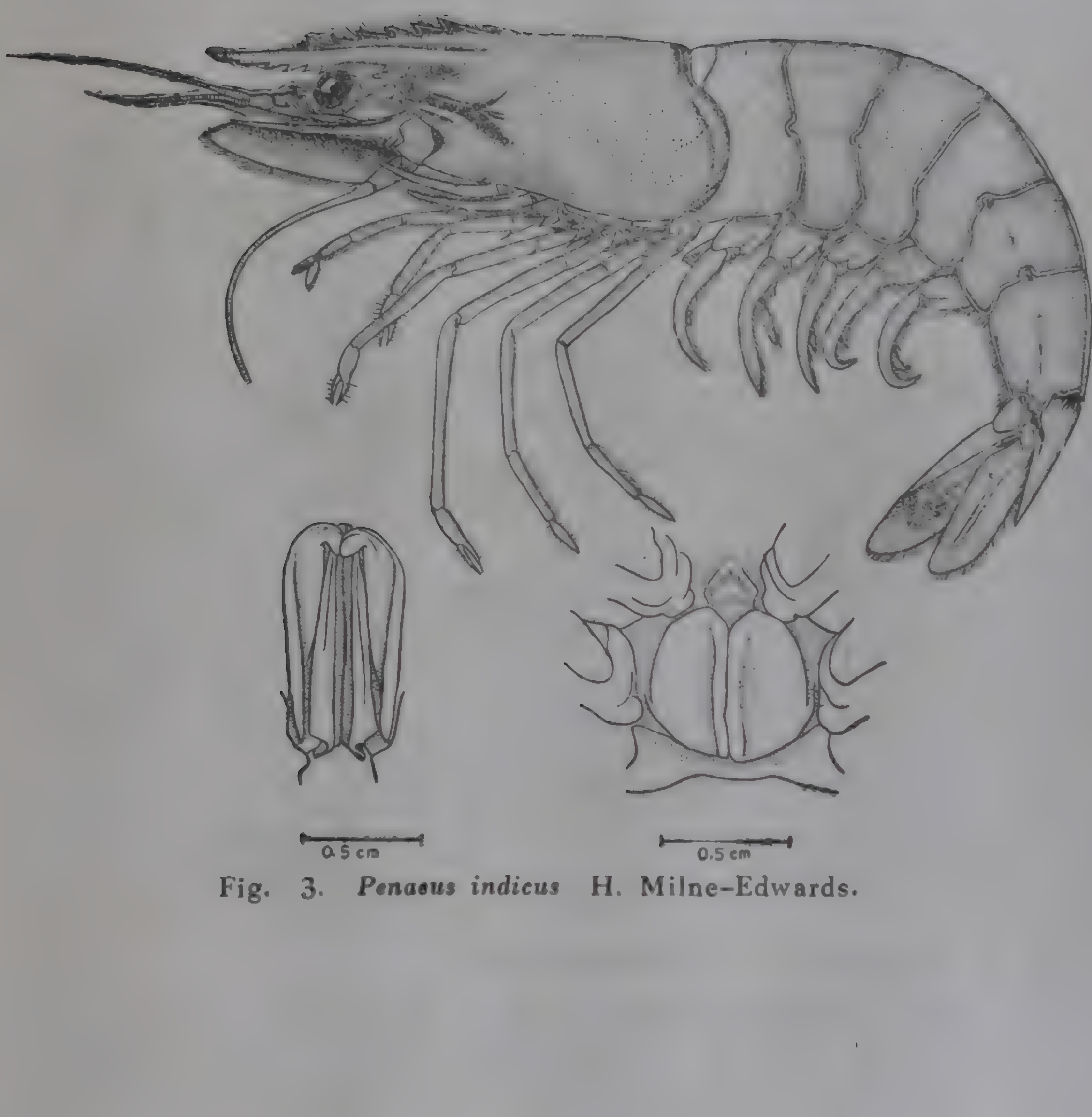

Fig. 3. ***Penaeus indicus*** H. Milne-Edwards.

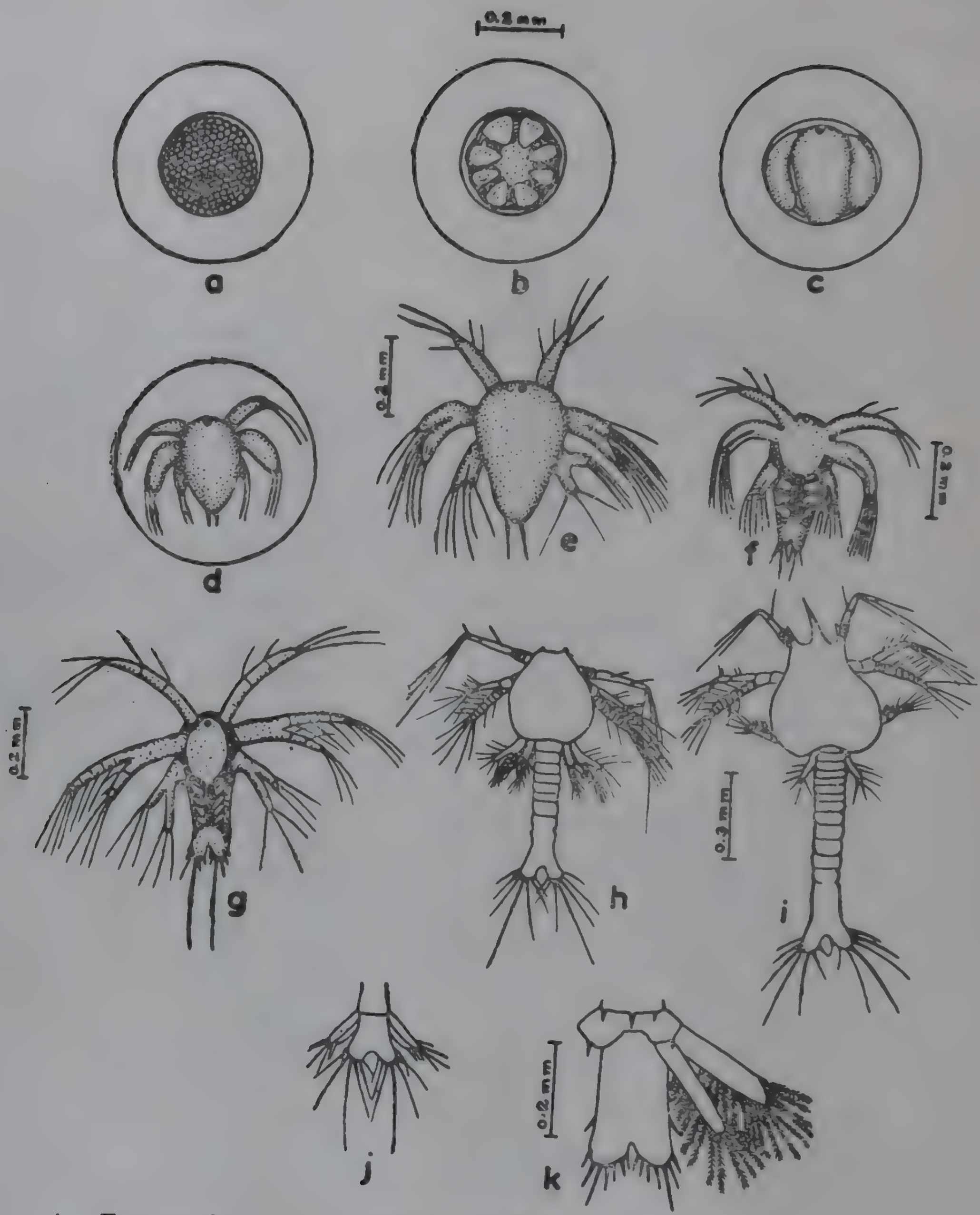

Fig. 4. Eggs and Larvae of *Penaeus indicus.*

a-d. Development stages of egg; e. Nauplius I; f. Nauplius II; g. Nauplius III (Subrahmanyam, 1965); h. Protozoea I; i. Protozoea II; j. Uropod and telson of Protozoea III; k. Uropod and telson of Schizopod I (Menon, 1937).

General colour of live specimens is translucent whitish, with numerous small brownish, greyish or greenish chromatophores scattered over the carapace and abdomen. The upper half of the rostrum, base of eyestalks, dorsal carina of the last three abdominal somites, telson and uropods are deeply pigmented with maroon and dull brown chromatophores. The antennae and the terminal portion of the exopods of the second and third maxillipeds are pinkish; the tips of both uropods and the external margins of the outer pair are pinkish-red with similarly coloured setae. The antennular flagella are lemon yellow, banded and dotted with maroon.

Distribution

The occurrence of *P. indicus* has been reported from New South Wales: off Broadwater; Queensland: Gulf of Carpentaria; New Guinea: Port Moresby; North Borneo: Labuan, Sandakan; Indonesia: Palembang, East Kalimantan, Java; Philippines: Manila Bay, St. Miguel Bay, Bulacan Province, Santa Cruz, Luzon; Singapore: Amoy; Andamans; East Pakistan; Gulf of Aden; east coast of Africa and Madagascar. The species is fairly widely distributed in the Indo-Pacific, ranging from coasts of India and Ceylon to the west through Gulf of Aden to east coast of Africa and Madagascar, to the east to Andamans, Malaya, Singapore and Indonesia. As a commercial fishery the species exists in India, Ceylon, Malaya, Singapore, Mosambique and Madagascar, but it is reported as of scattered distribution in Australia, New Guinea and the Philippines. It is considered rare in waters east and south-east of Borneo. In India the species supports commercial fisheries in both the marine and estuarine environments on the east and west coasts.

Biology and Life-History

Eggs and larvae:- Eggs of *P. indicus* have been reported to occur in large numbers in subsurface plankton in Madras waters (Subrahmanyam, 1965). They were obtained from 3 metres below surface in Fabruary 1964. These eggs have been referred to this species purely on the basis of circumstantial evidence of simultaneous occurrence of adults in mature condition. Panikkar and Menon (1956) stated that the species preferred ~~deeper~~ deeper waters for spawning, its eggs and larvae having been seldom obtained along with those of other penaeids known to exist in the same area. Menon (1937)

recorded three stages of protozoea and one of schizopod (mysis) (Fig.4 h to k) and Subrahmanyam (1965) described three stages of nauplius obtained by hatching the eggs collected from the Madras plankton (Fig. 4a to g). Menon's collections were from surface plankton, apparently indicating planktonic habits of the larvae. Collections made from areas near Cochin indicate that larger numbers of larval forms in advanced stages are present in the inshore subsurface waters particularly in the early hours of the morning.

Postlarval stages are well represented in the tow net collections taken from the estuaries near Cochin on the Southwest coast of India. George (1962) estimated the seasonal abundance of postlarvae of P. indicus (8 to 14 mm in total length) and studied the recruitment of these into the backwaters of Cochin. He observed that the postlarvae enter the Cochin backwaters in all the months except the period June to September and the peak recruitment having been observed in November-December and February-April. Hall (1962) observed that penaeid larvae and postlarvae (species not specified) formed only insignificant portion of the plankton collected from Singapore prawn ponds. He observed that more postlarvae were present in the inflowing waters than in the outflowing waters of the prawn ponds. It is possible that the post larvae settle down to the bottom of the prawn pond before the flow of tide reverses. Mohamed, Rao and George (1967) described the first post larva of the species and compared the distinguishing characteristics of the species with those of the co-existing species in Cochin backwaters
They found that the first postlarvae are fast swimmers performing rapid forward movement along the edges of the glass troughs in which they were placed.

Juvenile stages of P. indicus (30 to 120 mm total length) spend their life mostly in the estuaries and backwaters. On the southwest coast of India these juveniles support a good commercial fishery in the backwaters and paddy fields where they live till they attain lengths of 100 to 120 mm, after which they go back into the sea (Menon, 1954; Menon and Raman 1961; George, 1962). Recent observations made on the sizes of these prawns in the paddy fields at Edavanakkad, near Cochin showed that they grow even up to 160 mm in this enclosed environment. Hall (1962)

observed the maximum size of the species in the Singapore prawn ponds as 27 mm carapace length. This is about 113.4 mm total length as per the conversion rate given by him. The entire catch from the prawn ponds are therefore juveniles. The juveniles are bottom living and are obtained from the estuarine environment throughout the year.

Sexually mature adults occur only in the sea. They are associated with shallow coastal regions and muddy sea bottom which are subjected to changes due to the physical conditions of the coast line and the nutrients obtained from the land and rivers. De Bruin (1965) states that they prefer sand bottom and shallow waters of the sea within 2 to 6 fm (3.7 to 11 m). On the coasts of India the adults form part of the prawn fishery within 25 fathoms (45.8 m) in the sea. Its occurrence in the sea is subjected to seasonal fluctuations. George and Mohamed (1966) observed that the prawn fishery of Kanyakumari district (southern extremity of the west coast of India) is exclusively supported by large sized mature P. indicus.

Food and feeding:- Gopalakrishnan (1952) observed that the species does not show any significant difference in food habits in different months of the year. Analysis of the food of different sizes also showed no variations. Based on the periodic fluctuations of the various items of food consumed he observed that these prawns feed on whatever suitable material they come across. From laboratory observations he remarks that in the state of nature the species is partly predatory in habits and chase smaller creatures of a size which can be seized between the appendages. Larger crustaceans, fish and others are attacked only in dead condition. They usually prefer small particles of food, which are grasped by the chelae of the pereopods and passed on to the mouth. When bigger particles are taken up, more than one pereopod, with or without the assistance of third maxilliped, are used to catch hold of the prey. While capturing small ctenophores and medusae the pereopods hold the prey close to the mouth so that mouth parts can act on it.

Panikkar (1952) stated that the food of young penaeids consisted of organic detritus found in the mud, algal material and other extremely small organisms contained in the mud. Gopalakrishnan (1952) analysised

the gut contents of 380 specimens and found that vegetable matter and crustaceans formed the bulk of food consumed. Presence of other animal matter indicated omnivorous habits. The vegetable matter included diatoms like Coscinodiscus, Pleurosigma, Rhizosolenia, the planktonic alga Trichodesmium and cuttings of sea weeds. The Crustaceans included copepods, ostracods, amphipods, tiny decapods and their larval stages. Molluscan shell pieces, polychaetes, echinoderm larvae, hydroids, trematodes (living) and foraminifera were occasionally met with. Panikkar and Menon (1956) stated that the food of prawns (Metapenaeus dobsoni and P. indicus) consists of detritus, both animal and plant, that accumulate at the bottom of their habitats which are usually areas with muddy bottom. They seem to consume large quantities of algal matter when available, some of the stomachs examined having been practically full of it. Small living creatures like molluscs and worms, living at the bottom may also be taken in. Hall (1962) found that the food of the juveniles of the species from Malayan prawn ponds consisted of crustacea (small and large), vegetable matter and polychaeta. Larger specimens took in more crustaceans including penaeids and brachyurans.

Growth:- Hall (1962) estimated a growth rate of 0.102 mm in carapace length per day in prawns caught from Malayan prawn ponds and he considers this as fast rate of growth since limiting factors such as extreme temperature and scarcity of food are non-existent in that habitat. While studying the offshore prawn fishery of Cochin, George, et al. (in press) stated that the modes seen in the size frequency distribution at 126-130 mm for males and 141-145 mm for females represent the first year class, those at 161-165 mm for males and 171-175 mm for females represent the second year class and those above 195 mm represent the third year class. By following the progression of modes they have also estimated a growth rate of 20 mm in males and 15 mm in females during four months ~~the~~ between first and second year classes.

Hall (1962) has estimated the length weight relationship of the species as

$$W = 0.6918\ C^{2.922}$$

Where W is weight of prawn in grams and C is carapace length in cm.

Vast majority of this species caught from the estuaries does not exceed 120 mm. Menon and Raman (1961) have stated that under the prevailing conditions in their brackish water habitat most of the prawns move out into the sea or are caught before they are about 100 mm in length, although the adults may reach double that size. The rate of growth is relatively high when they are in the estuaries and backwaters which act as a sort of nursery ground for the species. Crosnier (1965) observed that favourable temperature of the environment accelerates the growth rate.

Movements:- The life cycle of the species is completed after passing through two distinct environments - the sea and the estuary. The larval development takes place in the sea, and the migration into the estuaries, lakes and backwaters commences when they are in late mysis or early postlarval stages. According to Panikkar and Menon (1956) large numbers of young ones pass into the backwaters before they are 10 mm long and this process of migration is continuous throughout the breeding period. The size attained by the species in the backwaters does not exceed 120 mm. Kemp (1915) records the highest size observed by him in the Chilka Lake as 120 mm. The seaward migration begins after this size is attained. The seaward movement is described as a passive process as they are usually carried by the large influx of rain water flowing into the sea during the monsoon period. Further growth, attainment of sexual maturity and other life processes take place in the sea. Shaikhmahmud and Tembe (1960) record that the species moves into Bombay waters in September to December and February to June, and that these movements mostly take place after heavy rains.

Hall (1962) demarcated the spawning ground of P. indicus about to 60 mi (80 to 96 km) from the Singapore prawn ponds and remarked that "migration of 40 to 50 n mi should be well within the capabilities of the mature P. indicus". Regarding the offshore prawn fishery of Cochin, George et al (in press) state that the females of the species belonging to the larger size groups move to still deeper waters or other areas for spawning activities and never return.

Maturation and reproduction:- P. indicus is heterosexual. Sexes can be distinguished by external characters such as presence of morphologically differentiated male and female sex organs. While the male sex

organ, is abdominal in position being the endopodite of the first pleopod; the female sex organ, thelycum, is a modification of the thoracic sternite. The presence of appendix masculina in the endopod of the second pair of pleopods is another male character. While the genital openings of the male are situated on the coxa of the fifth pair of walking legs those of the female are on the coxa of the third pair of walking legs. Females attain relatively larger size than males. Rao & George (1967) have traced the development of the external genital organs of the species from early stages to the adult form and found that over 50% of the individuals measuring 102.0 mm had their petasmal endopodites fused.

Menon (1957) reported that most of the mature individuals examined by him measured 150 mm and over, and hence he used this size as the limit to determine the proportion of mature and immature prawns in the samples. By observing the nature of the petasmal endopodites Hall (1962) observed that specimens below 23.4 mm carapace length were immature. Rao (1967) has studied the process of maturation of the species by ova diameter measurements and has statistically estimated the size of the females at first maturity as 130.2 mm. The smallest mature female actually observed by him was 134 mm in total length. The age of the species at first maturity has not been precisely estimated. George et al. (in press) have stated that females of 141 to 145 mm size group and males of 126 to 130 mm size group represent the first year class. It could therefore be assumed that the species attains sexual maturity at 130.2 mm, when about one year old.

The species is promiscuous. During mating the sperm packs known as spermatheca are deposited by the male in the external genitalia of the female. The females carry the spermatheca and the sperms are dispensed at the time of spawning. Impregnated thelycum is not differently coloured. Fertilization is external. As the eggs are extruded from the genital opening of the female the sperms are dispensed from the spermatheca.

Rao (1967) has estimated fecundity as 68,000 in a female of 140 mm total length, to 731,000 eggs in a female 200 mm long. The relationship of gonad size and egg number is not determined but the estimated relationship of body length to number of eggs produced is $\text{Log } F = -8.1277 + 6.0808 \text{ Log } L$, where F is the fecundity and L the total length of the prawn in

mm, with a regression coefficient of 0.9716.

Panikkar and Menon (1956) indicated the existence of two breeding periods namely October to November and May to June. Based on the occurrence of postlarvae of the species in the Cochin backwaters George (1962) recorded the spawning season as from October to May with two peak spawning periods in November to December and during February to April. Hall (1962) observed the spawning season of the species as February to April in Singapore waters. Subrahmanyam (1963) studied the gonad index of the species from Madras waters and observed that the breeding activity appeared to be pronounced in the months of May, July, August and September, and that there may be lesser breeding activity in March. George _et al._ (in press) stated that the species breeds throughout the fishing season with two peaks as observed earlier. Rao (1967) observed that _P. indicus_ has a prolonged breeding period extending from October to April in Cochin waters. In Madagascar waters Crosnier (1965) found that the breeding period of the species is closely related to the water temperature. In Ambaro Bay the spawning is spread out with one or more intense periods in the warm season. By closely following the sizes of the spawners during the breeding season Rao (1967) concluded that individuals of _P. indicus_ spawn five times during life time and that the interval between two successive spawnings is about two months.

Panikkar and Aiyar (1937) observed that the species did not attain sexual maturity in backwaters but their young ones were noticed in large numbers in the Adayar estuary when the bar was open to the sea. Panikkar and Menon (1956) stated that _P. indicus_ seemed to prefer deeper waters for breeding, its eggs and larvae having been seldom obtained along with those of the other prawns of the area, which liberate their eggs in coastal waters not exceeding 10 to 12 fm (18.3 to 22 mm) in depth. Shaikhmahmud and Tembe (1960) found the species represented in the Bombay catches by immature specimens although they observed a few mature females in November to December. Subrahmanyam (1965) collected freshly spawned eggs and nauplii from very close inshore waters of Madras, on the basis of which he suggested that the species might be breeding in the inshore areas. It is, however, generally believed that the species breeds in the sea in relatively deeper waters and the postlarvae migrate into the estuaries and

backwaters for feeding and growth. Hall (1962) demarcated the possible spawning area of the species in the Malayan region east of Singapore in 10 to 20 fm (18.3 to 36.6 m) depth between Lat. 01° 21' N and 01° 40' N Long. 104° 20' E and 104° 30' E. Based on the observations made on occurrence of protozoea and the trawl catches in Madagascar waters Crosnier (1965) observed that the species probably breeds in shallow waters of the Bay of Ambaro without any migration of the females taking place into the deeper sea.

The earliest developmental stage seen by Subrahmanyam (1965) was a blastula which was collected in the morning and he presumed that the spawning had taken place in the early hours of the morning. The eggs hatched out in the afternoon. On the basis of this the time taken for development is as follows:

12 (?) hrs.after spawning	.. hatch into	nauplius I
20 hrs. after hatching	.. ..	Nauplius II
44 hrs. after hatching	.. ..	Nauplius III
66 hrs. after hatching	.. ..	Protozoea I

Menon's (1937) collection of protozoea stages and first schizopod stage were obtained from plankton samples and hence the time required for development from one stage to the other is not given.

Fishery

Structure of the exploited population:- As a fishery the species is subjected to commercial exploitation at different stages of life from both estuarine and marine environments. George (1962) observed that the brood which comes into the backwaters in November to December reaches a size of 110 mm in September to October of the following year when they move out into the sea. He estimates a growth of 110 to 120 mm in the first year. Hall (1962) estimated that the species attains 27 mm carapace length (Ca.113.4 mm total length) in 10 months in Singapore prawn ponds. Therefore the entire prawn pond and backwater fishery are constituted by 0 year class prawns. George *et al.* (in press) observed that three year classes (0, 1 and 2) of this species are represented in the trawl fishery at Cochin.

In the backwater catches of Cochin the maximum size recorded is 140 mm. More than 80 percent of these catches were below 100 mm and the modal size groups were observed between 81 to 90 mm (Menon and Raman, 1961). In the inshore marine catches of Alleppey coast George (1961) observed its modal length shifting from 111-115 mm in July to 131-135 mm in October and at Chellanum from 111-115 mm to 126-130 mm from January to May and from 151-155 to 161-165 mm in September to December. At Narakkal the predominant size group was observed at 90-100 mm in January to February and at 131-135 and 141-145 mm in June, July and October. In the offshore trawl catches off Cochin 161-165 mm males and 171-175 mm females were found predominating the catches during early part of the season. Towards the close of the season the mode was seen at 146-150 mm for males and 156-160 mm for females. In Singapore prawn ponds the maximum size was 27 mm carapace length and the majority size was 10 to 20 mm carapace length (ca. 42 to 84 mm total length). In the commercial catches of Bombay, Shaikhmahmud and Tembe (1960) recorded 45 to 125 mm length range and 180-200 mm length range, the latter occurring only occasionally.

The sex ratio of the species obtained from the backwaters and from the inshore marine catches from Narakkal was studied in detail by Menon (1957). Data from Menon's work is reproduced in Tables I and II. His studies showed that the sexes were more or less equally distributed both in marine and in backwater environments. Shaikhmahmud and Tembe (1960) observed larger numbers of females in September and November in the commercial catches of Bombay. George and Rao (1965) found the distribution of sexes in the trawl catches of Cochin significantly different from what could be accounted for by the bionomial theory.

TABLE I

Sex ratio of *P. indicus* in Cochin waters (Menon, 1957)

Year	All size Ratio M	F	Over 120 mm Ratio M	F	Over 120 mm % in total M	F	Over 150 mm Ratio M	F	Over 150 mm % in total M	F
1952	41.6	58.4	41.4	58.6	82.9	83.5	36.5	63.5	29.9	37.2
1953	49.0	51.0	46.2	53.8	31.7	35.4	34.8	65.2	4.4	8.0
1954	51.0	49.0	51.0	49.0	77.0	77.0	49.4	50.6	29.0	30.9
1955	48.7	51.3	49.5	50.5	54.6	52.9	40.0	60.0	7.5	10.7
Average	49.0	51.0	48.8	51.2	59.8	60.2	44.6	55.4	16.5	19.7

TABLE II

Sex ratio of different sizes of *P. indicus* (Menon, 1957)

Size groups	Sex ratio M	F	Percentage in total M	F
Backwater catches				
Less than 120 mm	50.0	50.0	-	-
Sea catches				
Up to 120 mm	49.3	50.7	40.2	39.7
Between 120 and 150 mm	50.6	49.4	43.4	40.5
Over 150 mm	44.6	55.4	16.5	19.7
All sizes	49.0	51.0	-	-

M = Male; F = Female.

Fishing season:- In the backwaters of Kerala the species is fished almost throughout the year. The observations of Menon (1954) and Menon and Raman (1961) do not clearly indicate any seasonal preponderance of the species in the backwaters. The monthly percentage of the species in the paddy field catches and in the backwater catches are shown in Table III.

TABLE III

Showing the percentages of P. indicus in the commercial catches from the backwaters of Cochin

(Data for 1952 and 1953 from Menon (1954) and for 1956 to 1968 from Menon and Raman (1961)

	1952	1953	1956	1957	1958
January	11.7	9.0	-	15.5	-
February	8.4	7.0	-	11.7	-
March	12.5	29.8	-	28.5	4.8
April	2.0	48.0	-	15.0	-
May	-	-	-	10.7	2.2
June	-	-	-	25.0	8.0
July	-	-	-	8.8	20.4
August	-	-	-	-	4.1
September	-	-	-	-	-
October	-	-	-	1.9	-
November	1.6	-	4.3	15.6	-
December	8.7	-	2.5	7.6	-

In the Singapore prawn ponds Hall (1962) observed two peaks in relative abundance, one in March to April and again in September. According to Panikkar and Menon (1956): "Though a few prawns may be caught throughout the year at various points along the west coast (of India), the marine fishery is largely seasonal. On the west coast the season generally coincides with the monsoon period, June to September, so far as the southern region is concerned". This is a general observation based on overall prawn catches and not concerning a particular species. Besides, the introduction of mechanisation in the fishing industry in subsequent years has changed the pattern of succession of many a species in the fishery of this region. In the offshore catches of Cochin, George *et al*.(in press) found maximum abundance of the species during January to April. Early in the season, during September to October period, the species was conspicuously rare in the offshore catches. In the commercial catches of Bombay Shaikhmahmud and Tembe (1960) found the species occurring throughout

the year except during the months of January, July and August. Mohamed (1965) observed the species contributing substantially to the prawn landings at Sassoon Docks (Bombay) in certain months but there was no regularity in its appearance. Mohamed (1967) recorded the fishing season of the species in December to February in both the east and west coasts of India. George and Mohamed (1966) reported that *P. indicus* is commercially ~~x~~exploited in Kanyakumari District from May-June to September-October.

Depth ranges in which fishing is carried out.- The estuarine and backwater fishery for the juveniles of the species is carried out in very shallow waters not exceeding 10 m in depth. The depth of water in the paddy fields of Kerala, from where the species is fished in large quantities, and of the Singapore prawn ponds, is less than 1.5 metres. The commercial fishery for adults is generally carried out in the coastal waters up to a depth of 50 metres along the Indian coast. In Madagascar waters the species is generally fished from depths up to 10 metres.

Catches:- George (1961) has observed that the species formed 1 to 5 percent of the inshore marine catches at Alleppey, 10.3 to 75 percent at Chellanum and 3.5 to 33.3 percent at Narakkal, on the west coast of India. In the offshore fishery at Cochin George *et al.* (in press) recorded the highest value of 48 percent for the species in total catches. In Singapore prawn ponds Hall (1962) records *P. indicus* as forming 27.99 percent of the catches. Mohamed (1967) states that the species forms approximately 10 percent of the total marine prawn production of India. On the basis of this the total catch of this species per year in India is estimated as 8,000 tonnes.

Fishing equipment:- In the backwaters the species is caught in large quantities in stake nets, cast nets, drag nets, dip nets and small scoop nets. On Kerala coast there are conical sluice nets specially designed to catch all the prawns entering the paddy fields situated near the backwaters. All these nets are made of cotton twine. Some ingenious contraptions like 'changala pachil' (Panikkar, 1937), bamboo scree traps etc. are also in use in different parts of the estuaries and backwaters. In the inshore marine fishery the principal types of gear employed in the ~~xakp~~ capture of prawns are the boat seines and the shore seines. In Gujarat ~~employed in the capture of prawns~~

and Maharashtra States on the west coast of India large stake nets ('Dol net') are used in the inshore prawn fishery. Along the Kerala coast and on the southern end of the west coast of India cast nets of various dimensions form an important gear for capture of prawns. From the deeper regions prawns are caught in trawls and stake nets only. In the mechanised vessels the gear in use are the common 2 or 4 seam shrimp trawls having 13 to 18 metres headline. The mesh size of the various parts of the shrimp trawl are: the wings 76 mm, the belly 50 mm, the batings 38 mm and the cod end 25 mm. These nets are mostly made of cotton twine but in some cases synthetic fibres are also used. The bigger trawlers, however, use nets with longer headlines.

Small dug-out canoes (4 to 6 metres long) are the principal craft in use in the backwaters. Larger dug-outs (6 to 10 metres long), canoes and catamarans are used in the inshore fishery in the west coast of India. On the east coast plank built canoes and catamarans are in use. The shrimp trawls are operated from 7 to 11 metre pablo type wooden hull boats powered by 10 to 30 hp diesel engines. A few larger steel built boats are also operating shrimp trawls.

Possibilities of culture:- Farming and culturing of the species, in the strict sense of those terms, is not reported from any part of the world. The time old method of trapping of the juveniles ~~of this prawn,~~ along with those of other species, is extensively practised in the paddy fields of Kerala (Panikkar, 1937; Menon, 1954; Gopinath, 1956; Panikkar and Menon, 1956; Kesteven and Job, 1957; George, Mohamed and Pillai, 1967). Soon after the rice cultivation is over in October the paddy fields lying close to the backwaters and connected canals are prepared for the trapping of prawns. These preparations include strengthening of the bunds and refixing of the sluices which control the flow of water into the fields. The water is let in during the high tide and let out during the low tide. When the water is let out a bamboo screen is placed inside the sluice to prevent the prawns from escaping. During the night a petromax lamp (ca. 300 candle power) is kept over the mouth of the sluice in order to attract the prawns when the water is let in. Fishing is generally carried out during ebb tide at night when there is maximum tidal gradient due to the

spring tide. A conical net ~~(sluice net)~~ is fixed to the mouth of the sluice and the water from the field is let off virtually filtering through the net. The prawns are collected from the bag end of the net. The practice is described in detail by Menon (1954) and Gopinath (1956). Culturing in the strict sense is not involved in this practice as the prawns that enter the fields are neither tended nor do they remain there for significant length of time. But the recent studies made on this practice by George, Mohamed and Pillai (1967) have proved that the prawns entering the field do remain in these fields for some time during which they feed and grow. They ~~are~~ also found that these paddy fields are not merely a part of the trapping mechanism but that they provide an active and suitable biological environment for the life and growth of these prawns. Therefore it would follow that introduction of modern culture techniques into this age old system of prawn trapping would be benificial and result in improvement in the quantum of catches as well as the size of the prawns caught.

2. PENAEUS SEMISULCATUS DE HAAN, 1850

The ~~distinguishing~~ characteristics of the species (Fig.5), are as follows:

Teeth on rostrum 6-7/2-3, almost straight with a uniformly convex blade, reaching tip of antennular peduncle. Postrostral carina distinctly sulcate, the sulcus slightly less or equal to 1/3 length of carapace. Adrostral carina and sulcus reaching 2/5 length of carapace from posterior edge. Postrostral carina almost reaching posterior border of carapace. Gastro-orbital carina occupying posterior 2/3 distance between cervical sulcus and anterior margin of carapace. Orbito-antennal sulcus posteriorly deep and with parallel sides. Antennal carine 2/5 length of carapace, exceeding orbito-antennal sulcus posteriroly and meeting hepatic sulcus 1/3 its length from posterior end. Hepatic carina inclined downwards to horizontal at angle of about 15° and 1/5 length in carapace. Cervical sulcus upcurved, shallow and 1/4 length in carapace.

Upper antennular flagellum larger than lower, exceeding 1/2 length of peduncle. Prosartema reaching 1/4 of second segment of antennular peduncle; stylocerite attaining 1/2 of first segment. Dactyl of maxilliped III 2/3 length of propodus (in male) which bears an apical tuft of setae as long as dactyl. Maxilliped III reaching tip of basal segment as antennular peduncle. Pereopod I exceeding carpocerite by half the entire dactyl, pereopod II reaching or exceeding tip of first, pereopod III exceeding third segment of antennular peduncle, pereopod IV exceeding carpocerite by half the entire dactyl, pereopod V very slightly exceeding fourth. Exopods on all pereopods, an ischial spine smaller than basial, on first.

Abdomen dorsally carinated from fourth somite. Fourth and fifth somites each with 2 and sixth with 3 cicatrices. Telson unarmed.

Median projections of petasma flattened dorsoventrally, slightly overhanging lateral lobes; latter with minute spical spines, minutely tuberculate internally and externally but without distinct rows or areas of spines. Anterior plate of thelycum obtusely angled apically, with deep V-shaped excavation; a posterior tongue inserted between flaps of seminal receptacle for 1/3 their length. Width of anterior plate 1/3 seminal receptacle at its widest point. Seminal receptacle as wide as long, flaps strongly reflected with transverse striae on everted lips and almost angular at their lateral extremities.

Colour in life dark green with indistinct darker crossbands on the abdomen; antennal scales eyestalks, pleopods and uropods dull red, the latter with a brownish fringe, pereopods with yellow and reddish bands, antennae banded (adapted from Dall, 1957).

Distribution

This is also a widely distributed species in the Indo-Pacific region as the other two species discussed. It is reported from Australia: Queensland, Gulf of Carpentaria, Princess Charlotte Bay, Townsville, Repurse Bay; New Guinea: Kinikini Bay, Hercules Bay, Oyster Bay, Daru I., Yule I.; Indonesia: Java, East Borneo, Sumatra, Sulawesi, Lesser Sunda I., Mollucas, Halmahera I.; Philippines: Manila Bay; Japan: Seto Inland Sea;

Taiwan; South China Sea; Malaysia: Singapore, Malacca Strait; East Pakistan, Coasts of India and Ceylon, West Pakistan, Red Sea, East coast of Africa: Durban Bay, St. Lucia estuary, off Zululand coast, Richards Bay, Delagoa Bay; Madagascar: Cape St. Sebastian and Mangokay estuary.

Fishery and biology

Although the species is reported as forming part of the prawn fishery from many countries of the Indo-Pacific region, detailed information on its fishery and biology is scanty. The species is of commercial importance in certain areas of the Seto Inland Sea of Japan. Yasuda (1956) observed that the juveniles of the species measuring 3.2 mm to 17.0 mm in carapace length spend their life from late August to middle of October in areas of the sea where *Zostera marina* are growing. After middle of October the species seems to be fished only from the offshore areas where the bottom is muddy. It is also observed that the young prawn grows continuously and rapidly to adult size and then grow at a much reduced rate.

Hall (1962) found that *P. semisulcatus* formed 0.07 percent of the prawn catches (numerically) of the Singapore prawn ponds. He examined the stomach contents of 14 specimens and found the following food items:

Food item	Predominant	Residual	Total
Polychaeta	2	1	3
Small Crustacea	-	3	3
Large Crustacea	1	3	4
Pisces	1	1	2
Vegetable	-	2	2

Based on these observations he grouped the species among prawns with 'general carnivorous diet'. Weight length relationship of this species was expressed by the formula

$$W = 1.0069 \quad C^{2.727}$$

where *W* is weight in gms. and *C* is carpace length in cm. In Singapore straits the species probably breeds in the same breeding grounds of *P. indicus* in February - April (Hall, 1962).

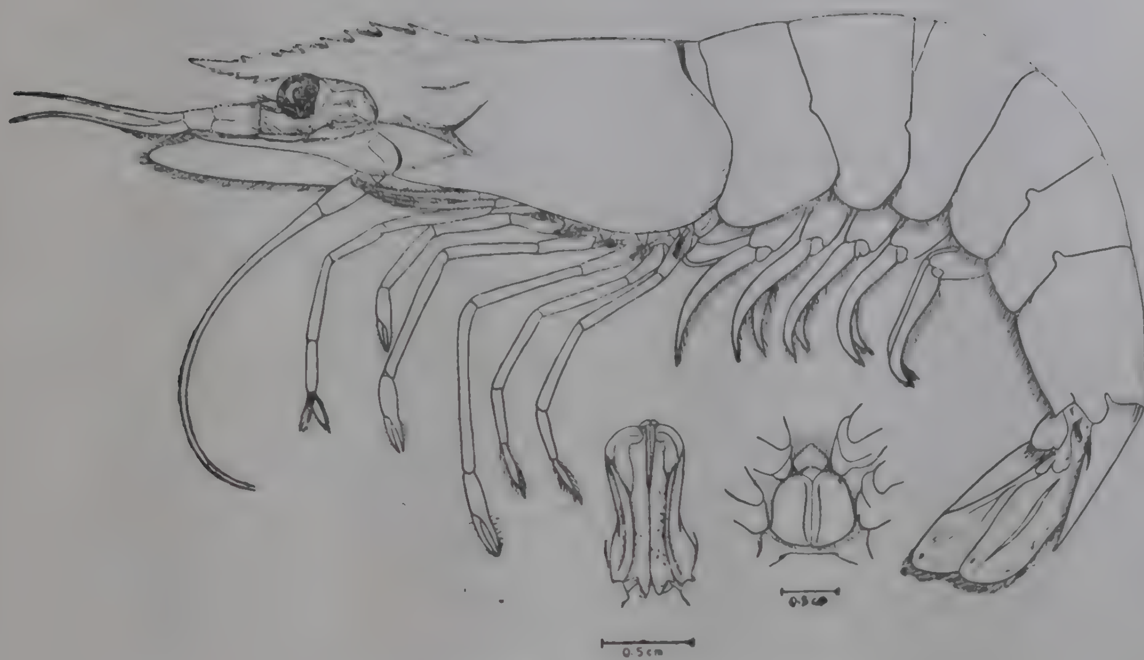

Fig. 5 *Penaeus semisulcatus* (Olivier)

Fig. 6 *Penaeus monodon* Fabricius.

In India P. semisulcatus is caught along with other prawns only occasionally. It is not known to contribute any significant portion of the marine catches. However, the species is often well represented in the brackishwater fishery of the west coast of India by juveniles measuring up to 150 mm. In the marine catches the size composition varies from 150 to 180 mm although the largest recorded size is 222 mm. From the general pattern of occurrence it would appear that this species also follows the same pattern of life cycle as that of the other penaeids of the area - sea to estuary and back to the sea.

Pillay (1954) observed the species forming significant portions of the prawn catches of the 'Bheris' (Brackish water areas) of West Bengal. He found that the larvae and the young are brought into the 'bheris' along with the tide during the winter months. They bury themselves in the muddy water of the ponds and grow very rapidly feeding on the food resources of the iliotrophic layer. A length of 3 to 5 inches (76 mm to 127 mm) is attained by the end of the season when most of them are caught and marketed.

On the east coast of Africa P. semisulcatus is found in large numbers in Durban Bay (Joubert, 1965). In the winter months (June - August) when there is a good growth of eel grass (Zostera capensis) on the central baks in the Bay large numbers of P. semisulcatus are found living in it. She found that the species was relatively scarce when the growth of eel grass was poor.

Based on the observations made in Java, Indonesia and India, Kesteven and Job (1957) considered the species as important for brackish water farming.

3. PENAEUS MONODON FABRICIUS, 1798

The largest of the marine prawns, this species (Fig. 6) is known as "Jumbo tiger prawn" in most of the countries of the Indo-Pacific region. The identity of this species was the subject matter of protracted discussions among carcinologists for over a century. This controversy has been finally resolved when Holthuis (1949) designated a neotype in the place of the lost real type of Fabricius. Description of the species is as follows:

Rostrum with 7-8/2-3 teeth, usually 7/3, exceeding tip of antennular peduncle and sigmoid in shape in juveniles and adults. Adrostral carina reaching almost to epigastric tooth. Postrostral carina often more or less flat with feeble indications of a sulcus, carina reaching almost posterior edge of carapace. Gastro-orbital carina occupying posterior 1/3 to 1/2 distance between postorbital margin of carapace and hepatic spine. Hepatic carina prominent, anterior half horizontal, the posterior often diverging very slightly below horizontal axis; distinctly separated from base of antennal carina which ends above middle of hepatic carina. Hepatic sulcus ill-defined. Cervical sulcus often with upper 1/3 indistinct, 1/5 to 1/7 length of carpace. Antennular flagella subequal or slightly longer than peduncle. Prosartema reaching to or barely exceeding tip, stylocerite attaining 1/2 basal segment. Endopod of maxilliped III reaching tip of antennular peduncle in adult male, reaching distal end of basal segment of antennular peduncle in females and juvenile males. Dactyl almost length of propodus in males, inserted at 1/5 length of propodus, the distal end of latter bearing a tuft of setae as long as dactyl. Dactyle 1/2 to 2/3 length of propodus in female and inserted apically. First pereopod reaching distal end of or slightly exceeding carpocerite, second reaching distal end of basal segment of antennular peduncle, third reaching to, or exceeding tip of peduncle by dactyle, fourth reaching as far as first, fifth exceeding fourth by dactyle. Ischial spine on first pereopod; no exopod on fifth leg.

Abdomen dorsally carinated from anterior 1/3 of fourth somite. Carina curving downwards fairly strongly towards posterior end of sixth somite. Fourth and fifth somites each with a small cicatrice, sixth with three cicatrices. Telson unarmed. Cardiac plate with 18-24 spinules, usually 20 to 24, zygocardiac ossicle principle + 9 to 12 conical teeth, usually 9 to 10, followed by several smaller teeth and a cluster of minute teeth; prepyloric acute with 6 to 8 large teeth, sometimes with 2 to 3 smaller teeth on lateral margin. Petasma symmetrical, median anterior lobe small, separated from lateral by a shallow notch, not projecting as far as lateral lobes. Lateral lobes without distal setae, with distolateral irregular group of ossicles greatly variable in number. Distal piece of appendix masculina 1.6 to 1.7 times longer than width, anterior rounded portion concave, posterior bluntly pointed inserted between flaps of seminal receptacles for 2/5 of their length. Seminal receptacles circular, flaps forming tumid reflected lips on mid line, with smooth inner edges in impregnated females (Dall, 1957).

Colour of fresh specimens dark blue to black, carapace and abdomen transversely banded, a pair of broad dark bands on each abdominal somite. Pleopods fringed with bright red setae. Pleopods and uropods tipped with light blue. Pattern of colour variable.

Vernacular name of the species in India:

Calcutta	..	Bagda chingdi
Madras	..	Yera
Kerala	..	Kara chemmeen
Mysore	..	Shetli, Shingde
Bombay	..	Jinga

Greatest recorded size is 337 mm.

Distribution

The species is fairly widely distributed throughout the greater part of the Indo-Pacific region. It is reported from Australia: New South Wales, Queensland, Western Australia; South of New Guinea, Philippine Islands, Celebes, Amoy, Formosa, Taiwan, Southern Japan, Malaya, Singapore, Mergui, East and west coast of India and Ceylon, Pakistan, east coast of Africa, Durban Bay, Mauritius, Madagascar. Distribution, therefore, ranges from South Africa to southern Japan and from Karachi to New South Wales. The species apparently prefers warm water habitats. It is recorded

from seas, rivers, estuaries, backwaters and even from freshwater.

Life history

Information regarding the eggs and larvae of the species is scanty. Panikkar and Aiyar (1939) report that the larvae enter Adayar backwaters (Madras) along with postlarvae during all the months that the bar remains open. Occurrence of postlarvae has been reported from the Chilka lake and Ennur backwaters by Kemp (1915). They are pelagic and are reported to live among weeds. Large numbers of them settle in weed pools and backwaters of the Gangetic delta, situated many miles away from the sea. Delmendo and Rabanal (1956) observed that the fry of the species are carried to the shallow coastal areas, tidal rivers and estuaries by the incoming tide. They also enter fish ponds through the coarse screen of the water control gates of the fish ponds. In the Philippines the fry are collected from these areas during May to October; peak occurrence being noted in August and September.

Kemp (1915) observed that the species is migratory in habit, the adults migrating out to sea during the breeding season. Throughout the Indian coast the species occurs both in the sea and in the backwaters in smaller quantities in relation to other commercial species of prawns. In the trawler catches of Kerala it is seen that the larger sized prawns are obtained from the deeper waters. In Bombay the catches mostly consist of immature specimens. Hall (1962) records the species among the catches of the Singapore prawn ponds.

Food and Feeding:- Hall (1962) found the following food material in the stomachs of the specimens of *P. monodon* examined by him:

Food item	Predominant	Residual	Total
Polychaeta	2	2	4
Small Crustacea	-	3	3
Large Crustacea	14	4	18
Insecta	-	1	1
Mollusca	1	5	6
Pisces	1	-	1
Vegetable	3	5	8

Small crustacean material was found only in the stomachs of prawns obtained from prawn ponds and mostly consisted of harpacticoid copepods.

Large crustacean food items were mostly of brachyuran origin. He observed three specimens having their food bolus divided into three parts, each having different food items. Based on this he observed that the species had been engaged in ingesting material of secondary choice when no opportunity was presented for ingesting preferential crustacean material. According to him the presence of split bolus was not indicative of varying feeding behaviour during different periods of the day. Food of the fry of the species observed in the Philippine prawn cultivating ponds (Caces-Borja and Rasalan, 1968) consisted of 'lab-lab', a biological asociation of minute plants and animals growing on the mud floor of the fish ponds. Different types of fungi, bacteria, diatoms, algae and small animals together constituted what is known as 'lab-lab'. It is also observed that these fry take raw, blanched or powdered fish flesh and rice bran when fed arteficially.

Growth:- From the available literature it is fairly clear that the species migrates into the estuaries and backwaters early in life. No information is available on its growth in the sea. The average growth observed by Delmendo and Rabanal (1956) in the Philippine nursery ponds where the species is cultured is given in Table IV. They further observed that the growth rate may be still faster and that the largest one-year olds may measure as long as 250.0 mm and weigh 120 gms while the smallest may be only 180 mm in length and 50 gms in weight. A kilogram of one year old 'sugpo' may contain 8 to 20 individuals

Nakano's experiments made in Taiwan, Formosa (Kubo, 1956) showed that P. monodon grew to 2.6-3.15 cm from 1.25-1.50 cm in 26 days when water temperature was 19° - 29°C. The prawns were fed once a day on the meat of atyid shrimp Neocaridina denticulata, oyster and small fishes. In another experiment he cultured the prawn in a pond together with Chanos chanos for 182 days feeding them with sardine meat. The water temperature was 29° - 35.4°C. The prawns increased in body length from 3.3 cm to 11.67 cm.

Weight length relationship of P. monodon was estimated by Hall (1962) as

$$W = 1.0000 \ C^{2.640}$$

where W is the weight of prawn in gms and C is the carapace length in cm.

TABLE IV

Average rate of growth of P. monodon under cultivation
(Delmendo & Rabanal, 1955)

Duration of culture	Total length in mm	Body depth in mm	Weight in grams
Fry	15.3	1.6	0.025
One week	21.5	2.5	0.06
Two weeks	28.2	3.6	0.08
Three weeks	38.8	4.5	0.02
Four weeks	45.3	5.7	0.78
Five weeks	57.1	7.8	1.63
Six weeks	60.3	9.7	3.30
Seven weeks	69.5	10.9	4.36
Two months	79.0	9.8	4.34
Three months	94.7	11.1	6.88
Four months	120.0	15.3	14.5
Five months	Incomplete		
Six months	141.9	18.3	22.3
Seven months	152.6	16.4	25.1
Eight months	Incomplete		
Nine months	178.0	27.8	57.3
Ten months	211.6	30.2	62.8
Eleven months	223.0	32.0	70.7
One year	229.8	32.0	95.1

Note:- The data for the ninth to twelfth months are for the 1951-52 season only and are therefore not strictly comparable with averages for the earlier periods.

Movements:- That the young ones of the species take shelter under weeds in the estuaries is reported by Kemp (1915), Domantay (1956) and Delmendo and Rabanal (1956). Kemp noticed that the young of the species ascends estuaries and makes its way to water of low salinity only in those seasons in which it is not breeding. The pelagic stages of larvae and postlarvae are apparently carried by tide well up into the Gangetic delta. According to him the adults annually resort to sea in the breeding season. Delmendo and Rabaal (1956) stated that it is probable that the

'sugpo' spawn in the sea not far from the coast and that the young are carried to shallow coastal waters, tidal rivers and estuaries by the incoming tide. They also enter fish ponds where they constitute a welcome and gratuitous addition to the cultivated fish crop. From the available information about this species, as well as others of the genus, it is quite clear that the pattern of movement seen in most of the penaeid prawns, sea to estuary and back, is followed by this species also.

Maturation and Reproduction:- *P. monodon* is also hetero-sexual. The sexes can be differentiated by the same characters as pointed out for *P. indicus*. Very little information is available about the spawning and reproduction of this species. Hall (1962) indicated the possibility of the species breeding in the same grounds as *P. indicus*, outside the Singapore waters, during the months February to April. It is quite possible that this species also breeds in the sea, in relatively deeper waters, from where alone large sized mature specimens are ever collected.

Information on the early larval history of the species is wanting. Kemp (1915) observed 10 mm long postlarvae in Chilka lake and Ennur. They are pelagic and transparent with a crimson streak running along the ventral surface, involving the whole of antennules and telson, but not the other appendages, except to a slight extent on the uropods. They possess two pairs of lateral spines on the telson and the rostrum; the latter in the youngest individuals is without inferior teeth, and extends a little beyond the eyes. Caces-Borja and Rasalan (1968) report the occurrence of 'Sugpo' fry (postlarvae(?) of *P. monodon*) as small as 8 mm (usually between 10 and 15.2 mm) in length along the shores of Manila Bay from May to October. They are easily distinguishable by the dark brown pigment running through their transparent bodies, making them appear like small pieces of broken stick or debris. According to Kemp, larger postlarval specimens are still slender, but are deeply mottled with dark grey and dull green. Panikkar and Aiyar (1939) found the larval and postlarval stages of the species entering the backwaters of Madras and state that they grow there for about a year, after which they go back to the sea to breed.

Habits:- *P. monodon* is extremely euryhaline in character and is capable of withstanding wide range of salinity. Panikkar and Menon (1956) observed the species even in the freshwater regions of Collair lake. To some extent they are eurythermal as evidenced by the wide gradient of temperature of the natural habitat of the species.

Fishery

Structure of the exploited population:- As in the case of *P. indicus* this species is also subjected to commercial exploitation at different stages of life from both estuarine and marine environments. On the basis of the growth rate observed by Delmendo and Rabanal (1956) it is clear that the entire backwater fishery and the prawn pond fishery are constituted by 0-year class prawns. On the same basis the species occurring in the trawl catches from both the coasts of India would come under late 0-year class or early 1-year class. In a general study Srivatsava (1953) observed that the Gulf of Kutch prawns (which includes this species also) have only one year span of life and perhaps die soon after spawning. Panikkar and Menon (1956) record 10 to 11 in. (25.4 to 27.9 cm) as its largest size in the marine catches off the coast of India. Present observations indicate that specimens over 300 mm in total length are common in the trawler catches landed from relatively deeper waters of the west coast. Shaikhmahmud and Tembe (1960) observed the species being represented in the stake net catches of Bombay with a size range of 100 to 150 mm.

Fishing season:- In the Kerala backwater fishery the species is caught throughout the season in small numbers. In the Gautami estuary on the east coast of India *P. monodon* is caught in all the months but the intense fishery is from November to early January (Subrahmanyam, 1966). In Bombay they are found in the commercial catches from August to October. Year to year variation in the fishing season is generally not evident.

Catches:- There is no reliable estimate of the quantity of the catches of this species in the commercial fishery. Mohamed (1967) gave a rough estimate of the contribution of the species in the overall prawn fishery of the country as 0.9 percent. Subrahmanyam (1966) estimated the

production of the species from the Gautami estuary as 500 tonnes in 1960-61 season. He also observed wide fluctuations in the yearly catches in the subsequent years.

Fishing equipment:- Same as that of P. indicus.

Possibilities of culture:- P. monodon is probably the most suitable prawn for culturing in confined waters under controlled conditions. The culture of this species is extensively practiced in Philippines and Formosa (Delmendo and Rabanal, 1956; Kesteven and Job, 1957; Caces-Borja and Rasalan, 1968). In the Philippines the 'sugpo' fry' (advanced post larvae) are collected, reared, transplanted and grown in culture ponds. The 'sugpo fry' are collected from natural waters of the tidal creeks by using 'bon-bon' lures made of a bunch of water grass and are transplanted to the nursery ponds. After attaining some growth the small prawns are collected from the nursery ponds and are stocked in rearing ponds, either by themselves or along with Chanos chanos. Best results are obtained when prawns are stocked alone as true culture. They are harvested twice - once at the time of transplantation to the rearing ponds and a second time at the final harvesting. They attain marketable size within six months to one year. The growth attained by the species during different periods is shown in Table IV. Delmendo and Rabanal (1956) record the following three factors which exercise some kind of limitations to this extremely lucrative practice:

1. Harvesting of the crop is rendered difficult due to the nongregarious habits of the prawn.
2. Rate of survival of the fry is poor, estimated at 10 to 50 percent.
3. Season for 'sugpo fry' collection varies from year to year and the supply fluctuates considerably.

IV GENUS METAPENAEUS WOOD-MASON & ALCOCK 1891

By

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IV GENUS METAPENAEUS WOOD-MASON & ALCOCK 1891

M.J. George

Species belonging to this genus are distributed throughout the Indo-Pacific region. In a recent revision of the genus Racek & Dall (1965) raised the number of determinable species included in the genus to 22. Since then 2 more new species have been described from Indian waters, raising the number to 24. Of these, 10 species have been recorded to occur in Indian waters. They are *Metapenaeus dobsoni* (Miers), *M. monoceros* (Fabricius), *M. affinis* (M.Edwards), *M. brevicornis* (M. Edwards), *M. ensis* (De Haan), *M. lysianassa* (de Man), *M. burkenroadi* Kubo, *M. stebbingi* (Nobili), *M. kutchensis* George *et al.*, and *M. alcocki* George and Rao. Among these, those species which are commercially important are dealt with in detail below with reference to their biology and fishery.

1. METAPENAEUS DOBSONI (MIERS 1878)

Common name

On the south west coast of India in the vernacular language the name "thelly chemmeen" is applied to the smaller sizes caught from the estuaries and backwaters and "Poovaalan or Kadal chemmeen" to the bigger sizes caught from the sea. On the north east coast it is known as "chingri". On the south east coast in Tamil Nadu it is known as "era".

Diagnostic features

Body lightly tomentose in patches. Rostrum extending a little beyong the tip of the antennular peduncle, with 8 or 9 dorsal teeth and having a well marked double curve. Anterolateral angles of the carapace without spine. The post-rostral crest fades away well in front of the posterior border of the carapace. The antennal spine is not very strong and not continued backward as a strong ridge, so that the post-antennular sulcus is not so deep as in *M. monoceros*. The anterior abdominal terga are not, or only most obscurely carinated (Fig. 7a-c).

The 5th abdominal somite about 2/3 length of the 6th, which is a little shorter than ~~xxxx~~ the telson. The telson shorter than the endopod of the uropod and without lateral marginal spines. The inner antennular flagellum longer than the outer, exceeding its peduncle in length.

All the legs are ciliated and the chelae weak. Strong spines present on the basis of all 3 pairs of chelipeds. In the male the basial spine on the 3rd pair is a long barb projecting considerably beyond the base of the merus. The last pair of thoracic legs do not nearly reach the middle of the antennal scale; in the male owing to a tiwst in the ischium, the large tooth (completing) the notch at the proximal end of the merus is turned forwards and outwards; anterior to this tooth there may be a second smaller tooth, but no row of denticles. In the adult female the last pair of thoracic legs is generally represented by a coxa to which is articulated a horny stump. No exopod on the 5th pair of legs.

The petasma (Fig.7b) is quite symmetrical. In the adult it consists of 2 rigid segments tightly folded in all their length, interlocked all along their anterior margin, and in close apposition along a great part of their posterior margin so as to form a compressed tube. Distally the tube ends in a pair of simple distomedian spouts; and where the spouts originate there are 4 papillae or short filaments, 2 anterior and 2 posterior.

The thelycum (fig. 7c) consists of a broad concave median tongue, more or less ensheathed posteriorly in a salient horse-shoe shaped process formed by the union of the lateral lobes of the organ itself. In impregnated females the thelycum is obscured by a pair of white conjoined pads which have a broadly triangular outline, tapering from a broad posterior base to a bluntly rounded anterior tip.

The species rarely exceeds 125 mm in total length.

<u>Colouration:-</u> In life it is semi-transparent; the pigment spots scattered on the carapace and abdomen are for the most part reddish, but tend to a browner shade on the rostrum and to a greenish tone on the posterior edges of each of the abdominal pleura. The antennules, antennae and antennal scales are dotted with red. There is a double row of reddish spots on the telson, the ~~margins being greenish~~. Both uropods are red at the tip,

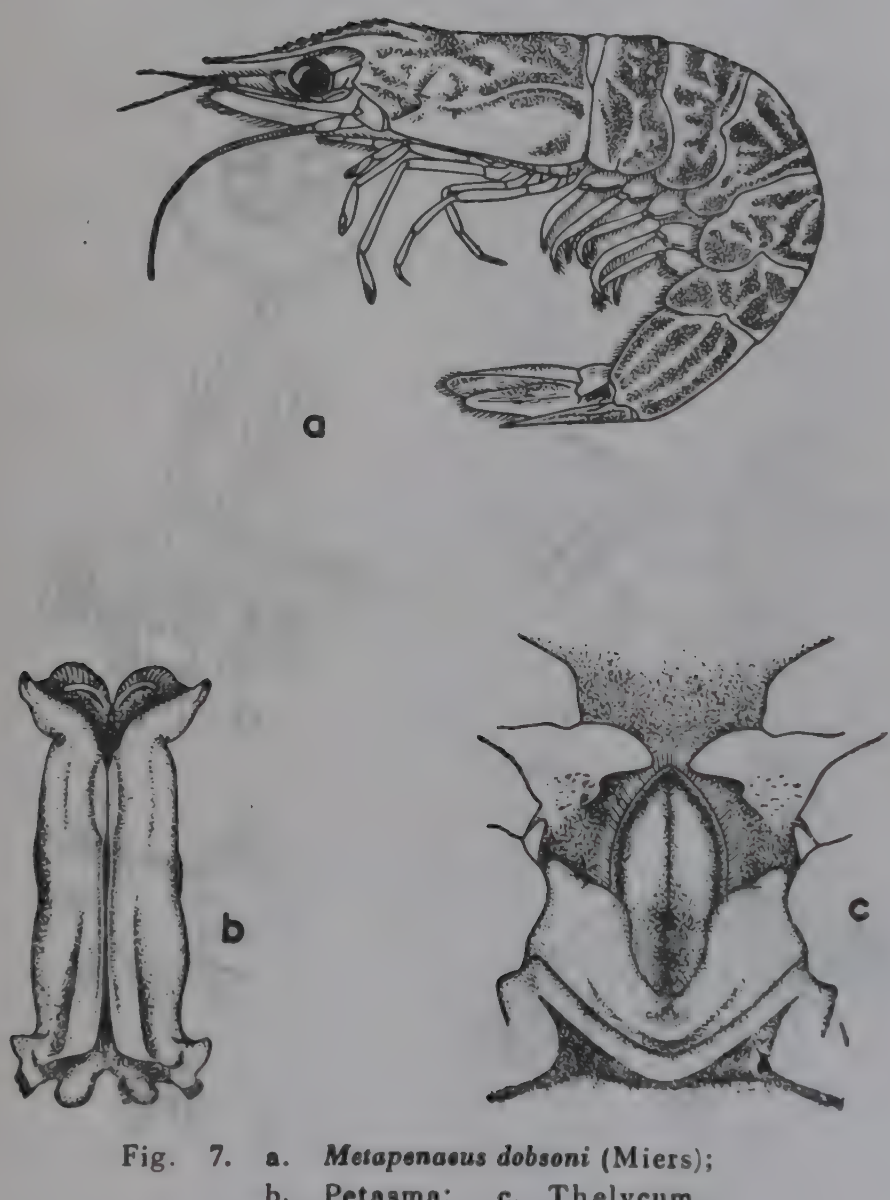

Fig. 7. a. ***Metapenaeus dobsoni*** (Miers);
b. Petasma; c. Thelycum.

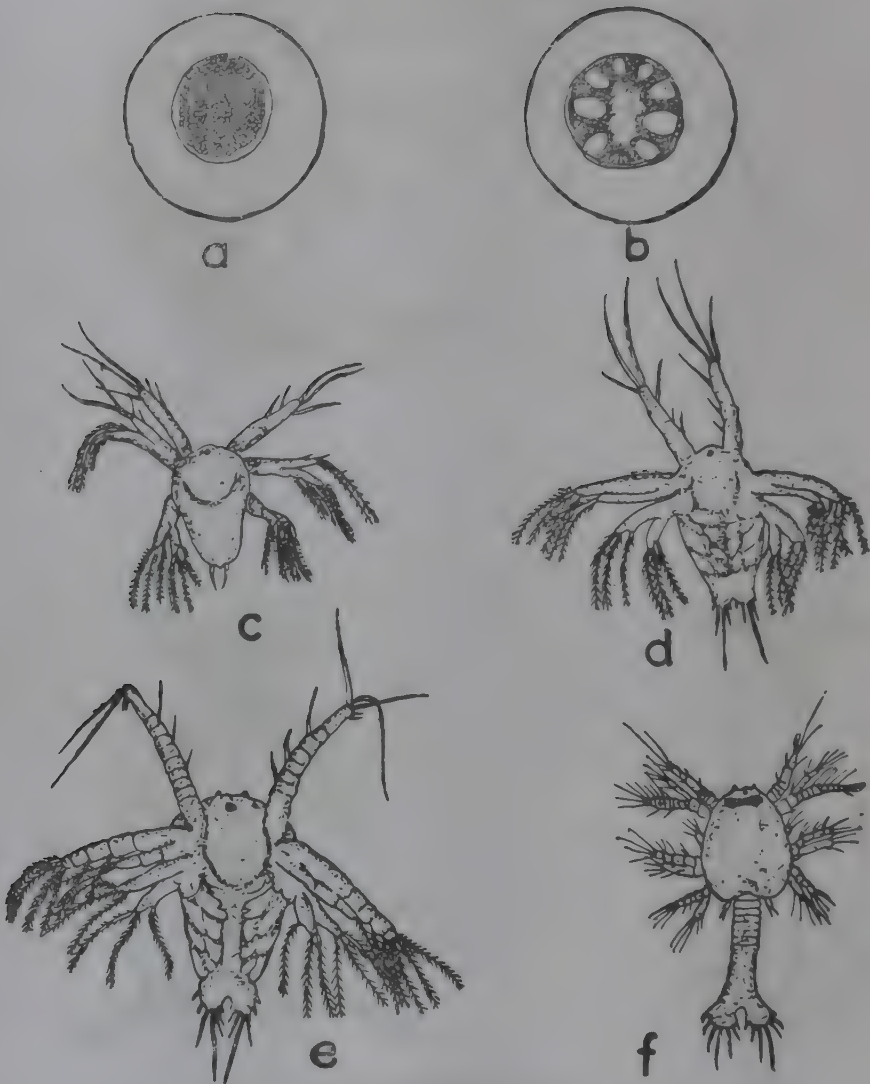

Fig. 8. *M. dobsoni* a–b. egg; c. Nauplius I;
d. Nauplius II; e. Nauplius III; f Protozoea I.

the exopods being also bordered with red externally and green internally.

Distribution

General distribution:- The species is distributed from Indian waters through Malaysia and Indonesia to Philippine Islands. According to the land and water areas code given by Holthuis & Rosa (1965) the distribution of the species in land areas is in 423, 424, 433, 434 and 437. In water areas it is distributed in the regions ISW and ISEW. It is found in brackish water as well as marine environments.

In Indian waters the species is present in the juvenile stages in most of the estuaries and backwaters along the coastline and the adults in inshore areas up to 20 fathoms depth with muddy bottom. It is more common along the south west coast of India, where it contributes to a major fishery.

Differential distribution of stages:- The eggs and larvae of this species are plenty at the surface and near the bottom from depths ranging between 2 to 15 fathoms in the inshore waters near estuaries throughout the coastline north of Quilon and south of Mangalore on the south west coast of India. The period of occurrence of these eggs and larvae is fairly long from September to April.

The early postlarval stages migrate into the various estuaries and backwaters along the Indian coast and the juvenile stages are abundant in these environments throughout the year and contribute to a good fishery. In the Cochin backwaters this migration commences at the late mysis stages and quite a large proportion passes into brackishwater areas before they reach about 5 mm length. Fairly large numbers of these postlarvae are observed in the backwater plankton in almost all the months of the year with two peaks, one in the months June through August and the other in November. Juveniles are present in the backwaters throughout the year and support a valuable backwater prawn fishery in the areas.

Adults are present in the inshore areas including the mud banks. They are present in slightly deeper regions where they support the trawl fishery.

Life history

Eggs and larvae:- The most highly developed ovarian eggs measure 0.32 mm. Eggs in different stages of development shown in fig.8.a-b are given by Menon (1951). They measure from 0.35 to 0.44 mm in size. Both the early embryos and the fully developed nauplii do not fill the eggs completely, a wide space known as the perivitelline space being left around them. The embryo is closely invested with a thin embryonic membrane which rapture later and the nauplius comes to lie within the egg membrane with appendages partly straightened out so as to occupy the entire space inside. Once the fully developed nauplii are seen inside the eggs hatching takes place in one or two hours.

The eggs are shed in the sea water and they hatch within 12 to 18 hours after spawning. The larval stages are planktonic and there is no evidence of the adults caring for the eggs or young ones. The 1st nauplius stage (fig.8c) hatching out of the egg has a pear-shaped unsegmented body with a pair of setae at the posterior end, a median eye at the anterior end and 3 pairs of appendages of which the anterior one is uniramous and the other two biramous. This nauplius undergoes two moults and the last nauplius stage shows considerable differences (Fig.8a&c). At the posterior end of the body there is bifurcate telson bearing 7 pairs of spines of unequal length. Rudiments of 4 pairs of appendages are developed behind the 3 pairs of the previous stages. The nauplius phase in the larval history lasts from 24 to 36 hours. The third nauplius moults into the protozoea which has a dorsal carapace in the anterior part of the body (fig.8f). All segments of the thorax are differentiated behind the appendages of the last nauplius. The abdomen remains unsegmented and terminates in the caudal fork with spine formula 7+7. Both mouth and anus are developed and the larvae feeds actively. There are two more protozoea stages (Fig.9a&b). In the 3rd stage all the abdominal segments are formed and the 6th segment possesses the uropods. The abdominal segments develop median dorsal and lateral spines. A well developed rostrum is present at the front end of the carapace and a pair of supraorbital spines also is present. Stalked eye with dark cornea are seen projecting from the carapace. The antenna is well developed and biramous carrying feathery setae and this

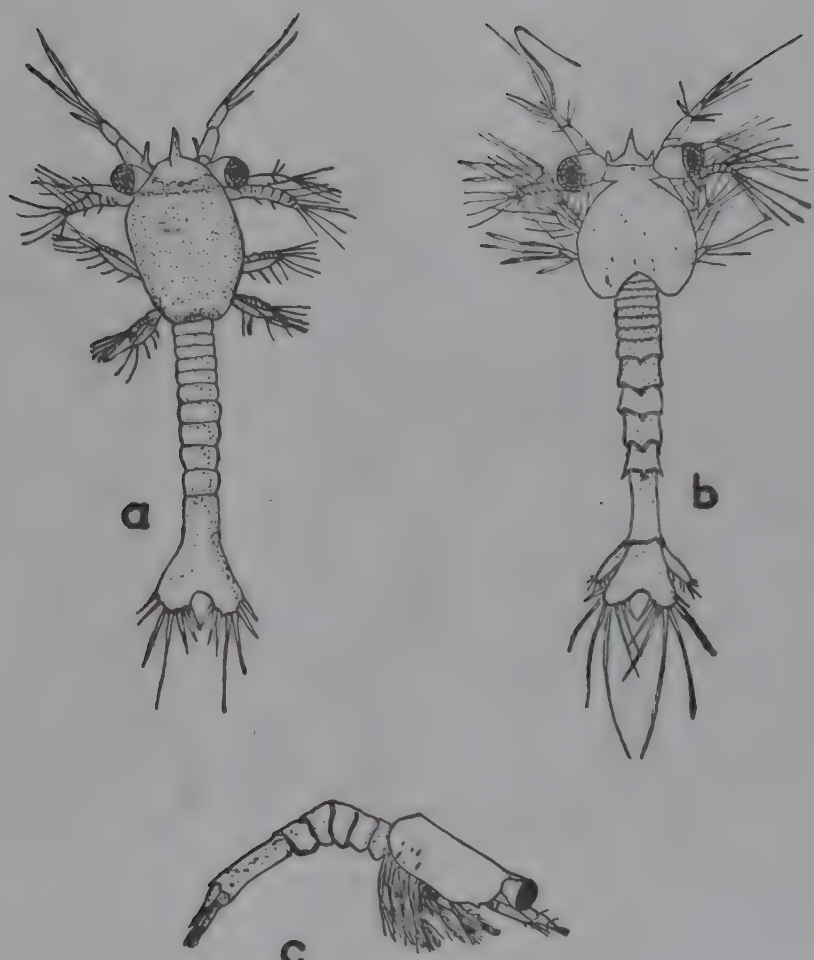

Fig. 9 *M. dobsoni* a. Protozoea II; b. Protozoea III; c. Mysis I.

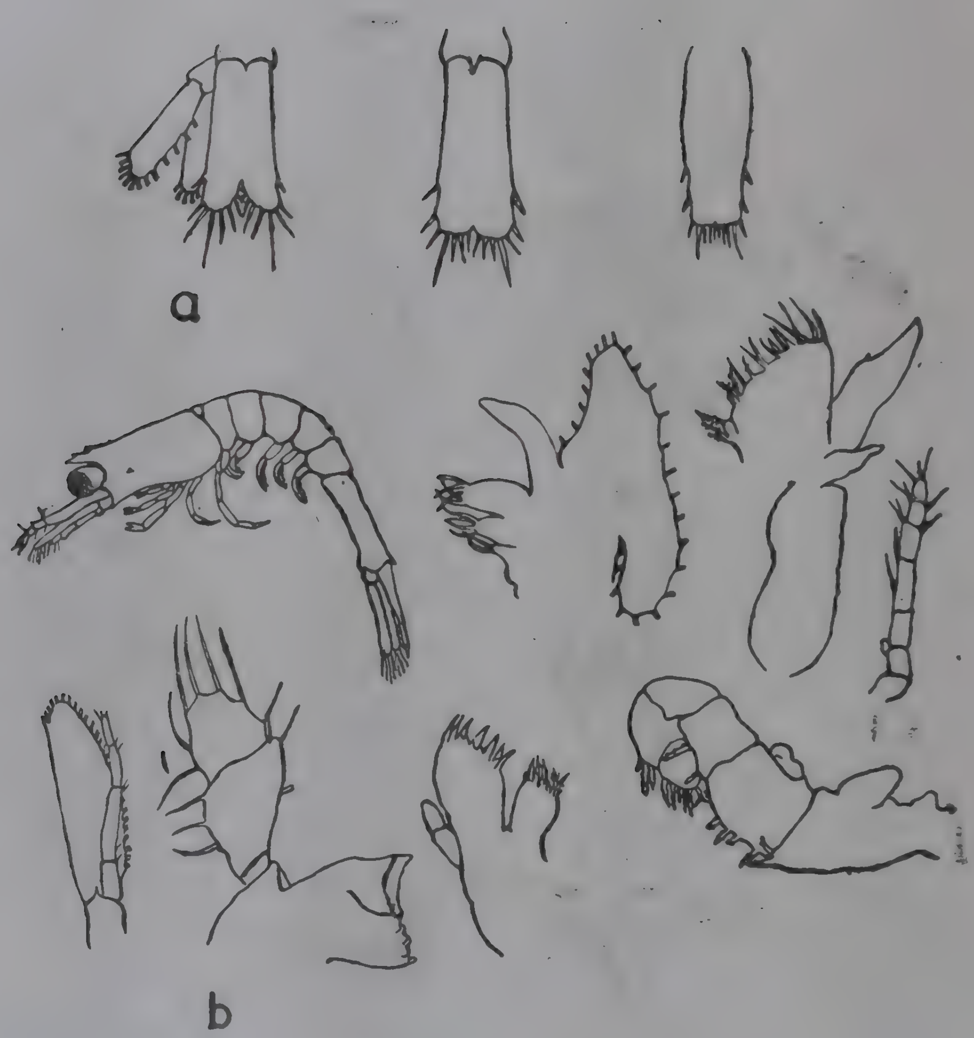

Fig. 10. ***M. dobsoni*** a. Telson of Mysis stages I to III; b. Post larva I and appendages.

is mainly used in locomation. The 3rd protozoea undergoes a moult and changes into the 1st mysis or zoea stage (fig.9c). The larva now has an enlongated somewhat laterally compressed body more or less similar to that of the adult prawn. There are 3 mysis stages during the moults of which exopodites tipped with feathery setae are developed on all the thoracic legs and pleopods appear on the abdominal segments. The forked telson of the protozoea changes into an elongated flat plate with almost parallel sides and a deep cleft on the posterior margin. This cleft gets less pronounced and disappeares in the last zoea stage (fig.10a). Gill rudiments also develop at this time. When the last zoea stage metamorphoses into the first postlarval stage 3 or 4 weeks after spawning the exopodites on the thoracic legs get reduced in size or disappear and setae are developed on the pleopods which become functional as the principal swimming organ, although remaining uniramous. A conspicuous hepatic spine appears on each side of the carapace. The cleft on the posterior margin of the telson disappears completely and spines develop on either margin of the posterior half which is narrower (fig.10b). This postlarva undergoes a series of moults occurring at intervals of about 2 days at first and subsequently becoming irregular between 3 to 6 days. Approximately 7 weeks are taken by the 1st postlarva to reach the 13th stage in which the rostrum with the full complements of dentation, the rudiments of the secondary sex characters etc. are present.

The larvae at nauplius stages do not feed, nutriments being provided by the yolk material inside the body. The protozoea, however, feeds actively on diatoms and other forms of phytoplankton mixed with microscopic animal forms. Mysis and earlier postlarval stages also thrive well on plankton containing a good proportion of algal constituents.

Nutrition and growth:- The food in general consists of varying amounts of organic matter mixed with sand and mud. Fragments or entire bodies of small animals and algae including diatoms compose the organic matter. The proportion of vegetable constituents has been found to be less in the larger individuals, as shown by the examination of stomach contents of prawns of varying sizes. The animal matter mostly consists of entire or partly digested forms of animal groups like Foraminifera, Copepods, Nematoda, Amphipoda, Gastropoda and Lamellibranchs. The

vegetable matter is largely constituted by fragments of the alga *Cladophora* and number of diatoms like *Fragilaria*, *Coscinodiscus*, *Pleurosigma*, *Navicula*, *Cyclotella* etc.

As the species is found in two different environments, the juvenile phase in the estuaries and adult phase in the sea, growth has to be considered in respect of these two environments. It is clear from the length frequency studies of the backwater as well as the marine catches that the juveniles in the former environment exhibit a quicker growth rate, which may probably be attributed to feeding and environmental factors. By laboratory rearing experiments in younger specimens and length frequency studies of the catches in the older specimens Menon in his studies (1951, 1954 & 1955) arrived at certain conclusions on the growth rate of this species and the size attained in successive years of growth. His results are tabulated below:

TABLE I

Growth rates of *M. dobsoni* in rearing experiments

Initial size (mm)	Period (days)	Final size (mm)	Increase in size (mm)
3.5	81	41.0	37.5
3.5	81	47.0	43.5
3.5	152	43.0	39.5
3.5	76	38.0	34.5
18.0	218	65.0	47.0

TABLE II

Length of year classes of *M. dobsoni*

Sex	1st year	2nd year	3rd year
Male	Abour 70 mm	About 90-95mm	About 110 mm
Female	About 75-80 mm	About 100-105mm	About 120 mm

However by extensive studies of length frequencies of catches from different areas as well as statistical analysis of samples by making use of Von Bertalanffy's equation a slightly different picture showing a faster

growth rate has emerged (George et. al. in press, George et al. (1968), Banerji & George (1967). The results of these studies may be summarised as to show a growth rate of 0.35 to 0.372 mm per day in the juvenile stages in the backwater and paddy fields. A size of about 90-95 mm is reached in the first year of life. After this the growth rate is much slow and the size reached at the end of the 2nd year is 115 mm. Thereafter there is very little growth taking place in the next year since almost the maximum size is reached by that time. The fishery of the region is thus constituted by the 0-year and 1st year classes.

Differential rate of growth in sexes, females showing a faster rate of growth has been noticed by most authors. The higher growth rate in the female becomes apparent quite early in life, even before reaching a length of about 50 mm.

Behaviour and movements:- As in most other penaeids the life cycle of the species is completed in two types of environments, (1) the brackish water of estuaries and lakes connected with the sea and (2) the sea. The entire course of larval development is passed in the sea. Migration into the backwaters commences at the late mysis or early postlarval stages. Very rarely a few late larval stages have also been encountered in the backwater plankton of Cochin. Large proportion of the young ones pass into the backwater areas before they reach a length of about 5 mm. During the breeding period successive batches of these young enter the backwaters. The maximum size of the species attained in the backwaters does not exceed 80 mm in length. Kemp (1915) recorded that specimens from the Chilka lake examined by him did not exceed 75 mm in length. The migration back to the sea seems to take place after this size is attained. The largest specimens, measuring about 125 mm, are found only in the sea. Breeding takes place only in the sea and the cycle is repeated after breeding. However it should be mentioned here that the inward migration of postlarvae does not necessarily imply that it is obligatory for completing the life cycle of these prawns. There is good evidence to show that even if they remain in the sea they may be able to grow and become mature. The small size of these prawns found in the catches of the shore seines operated along the coast line in certain season goes to show that these prawns in small sizes are present in the sea also.

A size oriented sexwise movement is noticed in the local populations in the inshore waters of Cochin. Menon (1957) observed that a good percentage of females of the larger size groups move out of the 10 fathom zone probably into deeper waters and reappear in the zone after about an years sojourn outside. But George et al (1968) proved that this particular species may be moving from the regular trawl fishing zone of 5 to 15 fathom to very near the shore; here they may concentrate in the mud bank areas during the upwelling taking place during the monsoon period.

On the east coast of India Subramanyam (1965) studied the migratory pattern of the species in and out of the Godavari estuarine system. He found emigration and immigration of the species more on new moon days than on full moon days. The immigrating prawns were usually more in numbers in the catches at dawn than those at dusk. The period of intense emigration was observed to be February and May. The size of the migrating prawn ranged between 11-15 mm and 86-90 mm size groups with the mode at 46-55 mm.

Large concentrations of prawns are known to occur in the mud bank areas along the south west coast of India. These are aggregation of several separate schools of a few species of which M. dobsoni is the major constituent. During the monsoon months when the mud banks occur at various places along the coast shoals of these prawns approach the shore in these areas so close as to make it possible for fishermen to use cast nets for catching them.

Reproduction:- The species is heterosexual as is the case with all the penaeid prawns. Externally visible genitalia are present by which the sexes could be distinguished. These are the thelycum in the female and the petasma in the male. The presence of appendix masculina on the endopod of the 2nd pair of pleopods is a secondary sexual charact possessed by the male. The long barb-like spines at the base of the las 3 pairs of pereopods are characteristics of the male. In this species i the adult female the last pair of pereopods remain stumpy. Since this a feature noticed in adult female only this is probably the result of in jury caused by the strong basial spine on the 3rd pereopods of the male during copulation.

In general the reproductive organs are paired and symmetrical. The ovary of the female extends almost the entire mid-dorsal region of the animal and the oviducts terminate at the genital pores at the coxa of the 3rd pair of pereopods. The testes of the male lies in the cephalothorax dirsolaterally to the hepatopancreas and the vasa deferentia open at the coxa of the last pair of pereopods.

Maturity of the gonads especially in females is attained only in the sea. In the case of males occasional specimens with mature gonads are met with in the brackish water environment. The minimum size at the maturity of the female is 64 mm in total length while in males it is slightly less. According to the nature of the ovary conditions different maturity stages have been observed viz., 'immature', 'early maturing', 'late maturing', 'mature' and 'spent recovering'. In mature specimens dark green ovaries are fully recognisable through the transparent dorsal chitinous shell.

Mating as in other prawns is promiscuous. Although no observations are available on the mating habits of the species there are evidences of mating taking place in the inshore waters of the south west coast of India. At copulation the males leave a white paid on the thelycum of the female as a stopper, with the spermathecae underneath. Impregnated females are found in large numbers in the catches during the breeding season.

Estimates of fecundity show a range of 34,500 to 1,59,000 eggs. According to Rao (~~IN PRESS~~ 1968) the number of eggs produced vary with size of the prawn in linear lagarithmic form and the formula is Log F = --07175+ 2.8473 log l. Fertilization is external, taking place at the time of spawning.

Studies at Cochin and other places along the south west coast of India indicate that the species spawn inside the 15 fathom area in the inshore waters. Though penaeid eggs are believed to be dermsal,large numbers of the eggs are found in bottom as well as surface plankton collections. This indicates that though spawning takes place near the bottom, due to the buoyancy of the eggs they are easily stirred up by disturbances

caused by currents or waves. The species show almost year round breeding with peaks in April, June through August and November-December and it is believed to spawn 5 times during its life time, first spawning taking place after 65 mm length is reached.

Population and fishery

Sex ratio:- The sex ratio of the species in the catches from the backwaters of Cochin as well as the inshore areas along the coast for several years have been described in detail by Menon (1955 & 1957) and are given in table III.

Table III

Sex ratio and percentage of *M. dobsoni* of different age groups in backwater and inshore fishery of Cochin.

Year	All sizes	Over 80 mm			Over 100 mm		
	Female	Female	% in total Male	% in total Female	Female	% in total Male	% in total Female
1952	52.9	57.4	20.8	25.1	70.7	8.7	18.7
1953	51.3	47.9	38.0	33.1	57.0	17.2	21.5
1954	45.7	43.9	56.8	53.0	73.0	12.4	40.0
1955	45.4	34.5	46.6	30.0	53.4	12.8	17.7
Average	48.6	44.0	41.5	34.5	64.3	12.6	24.0

The sex ratios of the different age groups are shown in Table IV.

TABLE IV

Sex ratio of different age groups of *M. dobsoni.*

Age group	Sex ratio	% in total	
	Female	Male	Female
Backwater catches - 0-year	50.0	..	..
All sizes from sea (0-3 years)	48.6	..	..
Upto 80 mm (1st year class only)	51.4	58.5	65.5
80-100 mm (2nd year class)	25.6	28.9	10.5
Over 100 mm (3rd year class)	64.3	12.6	24.0

From this he concluded that a good percentage of females of the 2nd year class moves out of the fishing ground, probably into deeper waters and

reappear in the zone after about an year. George & Rao (1967) statistically analysed the data on the sex ratio of the species and other prawns in the catches of the trawl fishery of Cochin for 1962 and 1963 (Table V). They found that in this species the distribution of the sexes varies significantly from month to month. It is suggested by them that the differential sex ratios may be the result of breeding migrations of females.

TABLE V

Sex ratio of M. dobsoni in the trawl fishery of Cochin during 1962 and 1963.

Months	Sample size	% males	Sample size	% males
January	993	43.0	1047	49.0
February	1057	44.0	1222	35.0
March	1743	32.0	997	39.0
April	919	45.0	1009	38.0
May	1127	48.0	1069	43.0
June	846	65.0	50	78.0
November	271	55.0	167	59.0
December	390	63.0	196	48.0

Age composition:- Taking the population as a whole the backwater and estuarine fishery is constituted by the 0-year class and the marine fishery by late 0-year class as well as 1-year class.

In the catches of the species from the trawl fishery of Cochin the first year class groups dominate in the beginning of the season from September-October to December-January. Thereafter the first year classes decrease and the late 0-year classes take the place. In the backwater fishery always only the 0-year classes are represented in the catches, up to 8 to 10 months olds. In the backwater and paddy field catches 3-4 months old prawns onwards are represented.

Age at first maturity will be about 6-7 months. Maximum age compute statistically is 3 years. Banerji & George (1967) have shown the species reaches a size of about 95 mm at the end of one year and about 115 mm at the end of the second year of its life. Late 0-year and 1-year groups are the maximum represented in the offshore catches.

Size composition:- In the whole population of the backwater and estuaries sizes ranging from 30 mm to 70 mm are found in the catches. In the marine fishery sizes range from about 60 mm to 125 mm. According to Menon & Raman (1961) in the stake net catches of the backwaters of Cochin the modal frequency of the species varied from 41-45 mm and 56-60 mm and the maximum sizes attained belonged to the 86-90 mm group, the proportion of which never exceeded 2 or 3 percent in any month. In the Godavari estuary the sizes ranged between 11-15 mm to 86-90 mm with the mode at 46-55 mm. In the trawl fishery of the area the modal size ranged between 91-95 mm 106-110 mm in the earlier months of the season while these sizes declined between 81-85 mm to 91-95 mm in the latter half of the season.

The size at first capture in the backwater fishery varied from 25 to 35 mm length. Size at first maturity is 64 mm according to Rao (op. cit). Maximum size attained is 125-130 mm group. Based on 15 observations Hall (1962) gives the length weight relationship formula as: $W = 0.7691\ C^{2.736}$ where W = weight and C = carapace length.

Abundance and density:- The abundance of the species in the trawl groupds of Cochin has been studied by George et al. (1968). The total size wise catch in numbers and catch per trawling hour o: the species given by them for 3 seasons are reproduced in Table VI.

TABLE VI

Total catch C (in 1000 numbers) and C/E (catch per trawling hour) of *M. dobsoni*.

Size in mm	1961-62 C	1961-62 C/E	1962-63 C	1962-63 C/E	1963-64 C	1963-64 C/E
41-45	..	..	11	3	..	..
46-50	..	..	23	7	3	2
51-55	..	..	35	11	13	8
56-60	9	2	48	14	25	14
61-65	63	13	105	31	57	33
66-70	117	23	385	116	132	77
71-75	730	148	847	254	239	139
76-80	1769	358	1124	338	284	165
81-85	3299	667	1386	416	263	152
86-90	5359	1084	1300	391	260	151
91-95	5429	1098	1428	429	251	146
96-100	6178	1250	1402	421	308	179

101-105	5188	1049	963	289	278	162
106-110	2051	415	377	133	108	63
111-115	2673	541	349	105	85	49
116-120	1352	274	183	55	46	27
121-125	238	48	14	4	..	..
126-130	11	2	..	..	..	..

They have calculated abundance of the species with sizes obtained in different months of the season and traced their movement in and out of different depth zones. Changes in abundance at the different depth zones are shown by them.

Natality and recruitment:- George (1967) has tried to correlate the natality and recruitment of the postlarvae into the backwaters of Cochin and the subsequent population contributing to both the backwater and marine prawn fishery of the species and expressed the opinion that this factor could possibly be used for forecasting of potential yields.

Recruitment of the species into the fishery of 3 centres along Cochin and Alleppey was studied by George (1961) and according to him recruitment of the older classes into the fishery commences by May onwards and along with that the catch per man-hour increases. Thereby showing a distinct relationship between recruit sizes and catch per man-hour so that with the least effort maximum catches are obtained.

The recruitment of postlarval stages into the backwater plankton of Cochin was made use of to determine the breeding season of the species by George (op. cit.). The seasonal pattern of recruitment was also studied by him. The seasonal pattern and variations in annual recruitment of the species in the fishery of different depth zones off Cochin was investigated by George et al.(op.cit.).

Mortality:- The total instantaneous morality rate of the species in the trawl fishery ground off Cochin has been worked out by Banerji & George (1967). The average annual total instaneous mortality rate based on 6 season's data was estimated by them as 3.56 and 4.04 respectively by 2 different methods. Based on the data on abundance and size in the fishery off Cochin from the season 1961-62 to 1963-64, George et al (1967)

estimated a monthly instantaneous mortality rate of 0.17 in one particular depth zone - zone II. From this the annual mortality rate works out to 2.04 in that zone. Considering the entire fishing area. pooling together all the zones (data given in table VI) the total annual instantaneous mortality rate (F+M) is estimated by them as 2.41 which is not much different from the estimate for zone II.

Population in the community:- In Cochin waters as well as all alon the west coast of India where there is fishery this species exist along wit other penaeid species. However, this is the major species contributing to the fishery. In the matter of total prawn landings there is very great difference between different centres as given by George (1961). There are wide fluctuations in the populations at Cochin as noticed by George et al and others. The nature of these may be summed up as given by George *et al.* (1967), as follows. "the distribution of abundance over the three years of observation show a decreasing trend, particularly in zone II where the maximum exploitation is taking place at present. Decreases in abundance in the same fishery from 1958-59 onwards also was observed, but the unusually large catches in 1961-62 tend to show that it is only due to natural fluctuations. The trend of decrease is continued later also as shown by the present study, and may well be attributed to natural fluctuations, especially when the instantaneous mortality of the major constituent of the fishery, *M. dobsoni*, is estimated as being very low (Banerji & George 1967). Nevertheless, this decling trend may cause apprehensions to the industry and has to be very carefully watched. The distribution of fishery effort, which is now concentrated in zone II where this trend is particularly evident, may be advantageously directed to the deeper zones where the possibility of better yield of large sized prawns, exist as pointed out here".

Fishing gear:- Different zies of aboat seines are the main gear employed in the fishing of the species along with other prawns in the inshore waters along the west coast of India. These nets are operated by the indigenous craft and are locally called 'thangu vala', 'vatta vala', koru vala' etc. Shore seines locally called 'kamba vala', 'nona vala' or 'kara madi' are also operated in this area for prawn fishing from the near shore areas. In the north Kanara coast shore seines called 'yendi bala'

are employed. In Bombay area bag nets or 'dol nets' are the gear operated in the shallow areas.

In the backwater and lake fishery the stake net ('ooni vala'), the chinese dip nets ('cheena vala'), the cast net('veechu vala') and the drag net ('vadi vala') are the important gear in use for catching these prawns. An ingenious method of fishing locally known as 'changala paachil' is also in use in Cochin backwaters (Gopinath 1953). A variety of wall nets are also used in many shallow areas along both west and east coasts. On the east coast a bottom drag net ('thuri vala') is used. Devices like long fences with rings of traps at the inner ends are employed for catching prawns in the inside waters along the east coast. In the paddy field prawn fishery of the south west coast conical nets fixed on rectangular frames are operated in sluice gates, as described by Panikkar (1937) and others. Hornell (1925 & 1938) describes several indigenous gears in which prawns are caught and their mode of operation in the Madras area.

After the introduction of mechanisation of fishing crafts in India conventional trawls of various sizes are in use in the trawl fishery for prawns from the offshore waters. In Cochin waters the most common shrimp trawl is the 2 to 4 seam trawl varying from 13 to 18 metres in head rope length and with mesh sizes of 76 mm, 50 mm, 38 mm and 25 mm for wing, body, throat and cod end respectively, used mostly by the smaller mechanised vessels. Bigger trawl nets are operated by a few bigger boats. The trends in development in the prawn fishing gears in India has been reviewed by Kurian (1965). Echo sounding equipments are used in all the bigger size boats for locating prawns.

Fishing boats:- On the west coast of India the indigenous gears are operated by the traditional dug out canoes and plank built boats with out-rigger. On the south west coast south of Trivandrum and along the east coast the catamaran is the craft used. In Godavari estuary two types of country craft are in use, namely, 'shoe-dana' and 'nava'.

In the mechanised fishery generally the medium sized pablo boats of 7 to 11 metre size powered by 10 to 30 b.h.p. engines are in use. A few slightly bigger type shrimp trawlers are present in some centres of operation. The trend in development is to construct bigger vessels to suit deeper water prawn fishing ventures.

Fishing areas:- Juveniles are fished in the backwaters, lakes and estuaries including paddy fields of Cochin backwaters in shallow areas ranging from 1 to 15 metres. Young adults and adults are caught from the sea in depths up to 25 to 30 metres. In the trawl fishery of Cochin George et al. (op.cit.) reports a concentration of the species in the 12-15 metre depth zone. Variations in abundance of the species in different depth zones has been studied. Muddy substratum is found most suitable for the species.

Fishing season:- In the marine inshore areas of south west India the fishery for the species is largely seasonal extending to several months. In the paddy fields of this region and in the Collair lake it is seasonal while in the backwaters of the same area it continues almost throughout the year. In the paddy fields of Kerala prawns are fished from the middle of November to the middle of April. In Collair lake the fishery is from May to December. In Godavari estuarine system migrant prawns of this species are abundant from November to May with peak periods in January and February. The marine fishery of the south west coast ~~xxx~~ coincides with the monsoon period, usually from June to September. Tables VII and VIII show variations from month to month in the percentage of M. dobsoni in the prawn catches of Kerala. Table VII refers to the fishery for juvenile prawns in paddy fields and backwaters and shows M. dobsoni to be the dominant species from August to April. Table VIII refers to the inshore marine fishery and illustrates that the percentage of M. dobsoni in any month may vary considerably from year to year. The offshore fishery in this area extends from about November to June with a peak in the 2nd half of this period.

TABLE VII

The percentage values (Numerical of M. dobsoni in the monthly prawn catches from paddy fields and backwaters. Dashes indicate no record available.

Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.
1951-52	-	74.6	81.6	80.8	79.2	84.5	-	-	47.0	74.8	75.4	91.3
1952-53	87.9	82.3	89.8	89.5	67.1	45.7	42.1	29.6	46.6	66.5	71.3	80.8

TABLE VIII

The monthly average percentage values of *M. dobsoni* in the marine prawn catches at Narakkal

Year	April	May	June	July	Aug.	Sept.	Oct.
1952	74.0	41.6	38.5	79.6	55.8	8.2	-
1953	-	26.3	55.3	24.0	33.5	51.0	16.2

The marine fishery in south west India shows local variations in the times of beginning and ending and also peak occurrence, varying up to 2 months this side or that. The formation of mud banks, locally called "chaakara" is noticed to influence the inshore fishery of Kerala coast. Here intensive fishing for prawns, particularly this species, is found to commence only with the formation of these mud banks. Other factors suggested to have some influence on fishing in the backwaters of Kerala and other areas are rainfall and lunar periodicity. The influence of lunar periodicity on immigration and emigration into the Godavari estuary was studied by Subrahmanyam (1965) and he found more on the new moon days than the full moon.

Fishing operation and results:- George (1961) studying the prawn catches, mostly contributed by this species, from three centres along the Kerala coast during the years 1956 to 1960, used total effort and intensity of fishing to establish a relationship between catch per man hour and recruit sizes.

In the trawl fishery of Cochin, George et al (in press) observed the effort and intensity of fishing through the years 1958 to 1963 and reached the conclusion that there is no overfishing in the area. George et al (1967) utilized the catch and effort data till 1964 for determining the abundance and its variation in the Cochin grounds.

The total catches of this and other species at the inshore fishing centres at Alleppey, Chellanam and Narakkal on the Kerala coast have been given by George (1961). Wide fluctuations in these catches were noticed by him in the years 1956 to 1960. Menon and Raman (1961) gave total catches of prawns at two centres in the Cochin backwaters. The trawl catches

of Cochin for the years 1957 through 1963, also show year to year fluctuations. The total catch figures of boats operated by the Indo-Norwegian Project and the Deep Sea Fishing Station of the Government of India in respect of this particular species for 1957 to 1963 (Table IX) are given by Banerji (1965) and Banerji and George (1967).

TABLE IX.

Trawler catches of M. dobsoni off Cochin.

Year	Catch (kg) C	Effort (Tr. hour) E	$U = \frac{C}{E}$
1957-58	99,301	2,734	36.32
1958-59	146,768	3,526	41.63
1959-60	67,320	3,958	17.01
1960-61	40,073	2,611	15.35
1961-62	174,121	4,547	38.29
1962-63	50,349	3,793	13.27

Subramanyam (1965) gives the total catches of the species along with other species for new moon and full moon periods separately in the Godavari estuarine system on the east coast of India. He also gives high tide and low tide catches of these prawns. Annual reports of the Indo-Norwegian Project show the total catches of this species caught by their mechanised boats at different centres on ~~east~~ both coasts of India.

Protection and management:- On the south west coast of India the only regulation now in existence is in respect of the paddy field fishery in which this is the most important species. The fishery is allowed ~~to~~ to operate from the middle of November to the middle of April only. According to Panikkar and Monon (1956) "this is done not so much in the interest of the fishery as in that of rice cultivation". They are of the opinion that "the methods of fishing now in vogue do not involve the destruction on any appreciable scale of prawn fry and leave sufficient numbers of breeding females to replenish the stock. The fear of depletion has not

therefore arisen anywhere and thus no serious problem in management, requiring regulation of the fishery, has confronted the Government of the various States". There is a licensing system for the cast net, stake net and chinese net fishery and paddy field fishery of the backwaters of the south west coast of India.

<u>Prawn culture</u>:- There is no farming or culture of this species anywhere. Trapping of adolescent stages, mostly this species, is prevalent in the extensive rice fields of coastal areas of Kerala in South India. A few decades ago actual culturing by rearing young prawns for 2 or 3 months used to be in vogue there, but the current practice seems to be only to trap the shrimps in the paddy fields with the incoming tide, after the annual crop of rice, and to fish them during favourable low tides at night. Soon after the rice cultivation, in about October, blocks of individually owned fields are leased to prawn fishermen for about 5 months. The dykes are strengthened and sluice gates installed. The flow of water in and out of these fields is regulated through these sluices. The water is let in at high tide and out at low tide. During favourable low tides at night a conical bag-net is fixed at the opening of the sluice, While letting in water at high tide and while fishing, a lamp is hung at the mouth of the gate. In these fishing processes very little attention to the stock is called for, although during the few hours or days that the trapped shrimps remain in the field they utilise the food organisms within the field and grow to a certain extent.

2. METAPENAEUS MONOCEROS (FABRICIUS 1798)

Common name:- Vernacular names:

India -	Kerala coast	-	Choodan chemmeen
	Bengal coast	-	Koraney chingri, Honya chingri
	Bombay coast	-	Jinga
	Gulf of Kutch	-	Sonayya jacha
East Pakistan		-	Kucho chingri
West Pakistan		-	Kiddi

Diagnostic features:- Body covered with a harsh and very short tomentum. Rostrum nearly straight, uptilted, reaching nearly to, or a little beyond, the tip of the antennular peduncle; armed with dorsally 9-12 teeth, which do not form a crest. Post-rostral carina continued to, or almost to, the posterior border of the carapace. Anterolateral angles of carapace broadly rounded off. A very small supra-orbital spine present. Antennal spine strong, produced as a salient ridge to the base of the small hepatic spine, the ridge bounding a well marked post-antennular groove which meets the cervical groove. Gastric region defined anteriorly, on either side of the rostrum, by a short oblique post-orbital sulcus. Branchial region defined anteriorly by a deep and narrow crescentic groove (anterior part of cervical groove) which embraces the base of the post-antennular ridge and meets the post-antennular groove and superiorly by a sinuous ridge (most distinct in its posterior half) which runs from the hepatic spine almost to the posterior border of the carapace (Fig.11a).

The abdominal terga are carinated mid-dorsally, the 1st, 2nd and 3rd bluntly, incompletely and somewhat inconspicuously, the 4th to 6th very sharply and almost completely. The 5th abdominal somite is about 2/3 length of the 6th and the 6th a little shorter than the telson which is shorter than the inner caudal swimmeret and without marginal spines.

Eyes very large; slightly surpassed by the antennular scale. The outer antennular flagellum which is slightly longer than the inner is not much more than half the length of its peduncle.

The 3rd maxillipeds barely reach the middle of the antennal scale; their dactylus in the male is not modified, but consists of a slender, setose, tapering joint about 4/5 length of the propodite with which it is articulated end-on.

There is a strong antrose spine on the basis of all 3 pairs of chelipeds. In the adult male the last pair of thoracic legs has the proximal end of the merus notched on its outer side, the notch being deepened anteriorly by a large retrose and introrse, hook-like spine and posteriorly by a subterminal lobule on the posterior border of the ischium. Beyond the spine the edge of the merus is finely denticulate. In both sexes the three terminal joints of these fifth legs are slender, and the dactylus rarely reaches much beyond the middle third of the antennal scale. No exopodite is present on the fifth pair of legs.

The petasma is quite symmetrical (fig.11b). In the adult it consists of two rigid segments tightly folded in all their lengths interlocked all along their anterior margin, and in close apposition along a great part of their posterior margin, so as to form a compressed tube. The median lobe is distally produced into a large gargoyle. The lateral lobes end in 3 projections, masked by the hood-like projections of the median lobes on the ventral side. The dorsal lobule of the median lobe is produced posteriorly into a prominent projection with rounded apex. On both sides of these projections the posterior margin is raised into well calcified triangular peojections. The lateral sides are well calcified, the posterior edge of which gently curves up sidewise.

The adult thelycum (fig.11c) has a concave central region bounded anteriorly by the median plate, laterally and posteriorly by the lateral plates and dorsally by the posterior hollowed out region of the median plate, the two oval plates on the sides of these and the anterior hollowed out regions of the lateral plates. The lateral ridges of the lateral plates are considerably raised to form an ear shaped structure. The anterior edge of this ridge possesses sparesely set small setae. The anterior half of the median plate is broader and has a distinct groove medially. The posterior half is narrower and descends down forming part of the roof of the concave portion, the posterior tip ending int two slightly elevated

knobs. The portion of the concave region between this posterior part of the median plate and the lateral plates is occupied by the two oval plates. The anterior margin of the median plate is beset with setae. The lateral sides of the same also possess setae especially the middle region. The coxae of the 4th pereopods have a sharp vertical ridge which is in close approximation with the sides of the median plate. The posterior ridge of the last thoracic sternite is beset with long setae.

The species attains a maximum length of about 180 mm.

Colouration:- They are semitransparent, closely covered with small reddish chromatophores. The dorsal carina of the carapace, rostrum, the bases of the eyestalks, the dorsal abdominal carinae and the carinae of the telson and uropods are defined by dull red pigmentation. The antennae are bright red. The first two legs are more or less colour less and the last three with numerous red chromatophores. The setae that fringe the uropods are golden red and the exopod of the uropod is bright red along its external margion.

Distribution

General distribution:- The species is distributed in South Africa, Mediterranean and Indian seas to Malaysia with the eastern limit as Malacca Strait. Under the FAO distribution code (Holthuis and Rosa 1965) the distribution of the species in land areas is in 122, 136, 154, 413, 421, 423, 425 and 556. In water areas it has a distribution in the regions ISW and ASE. Although it is a marine species it is found in marine, brackish water and fresh water environments.

In Indian waters it occurs in the juvenile stages in most of the estuaries and backwaters with muddy bottom along the coastline and adults in the sea up to 50-60 m depths, both muddy as well as sand and silt bottoms.

Differential distribution of stages:- There is no information on eggs and early larvae. Late mysis and postlarval stages of the species migrate into backwaters and estuaries all along the coastline of India and the juveniles contribute to a fishery in these waters. Based on the occurrence of large numbers of the postlarvae in the Adayar estuary

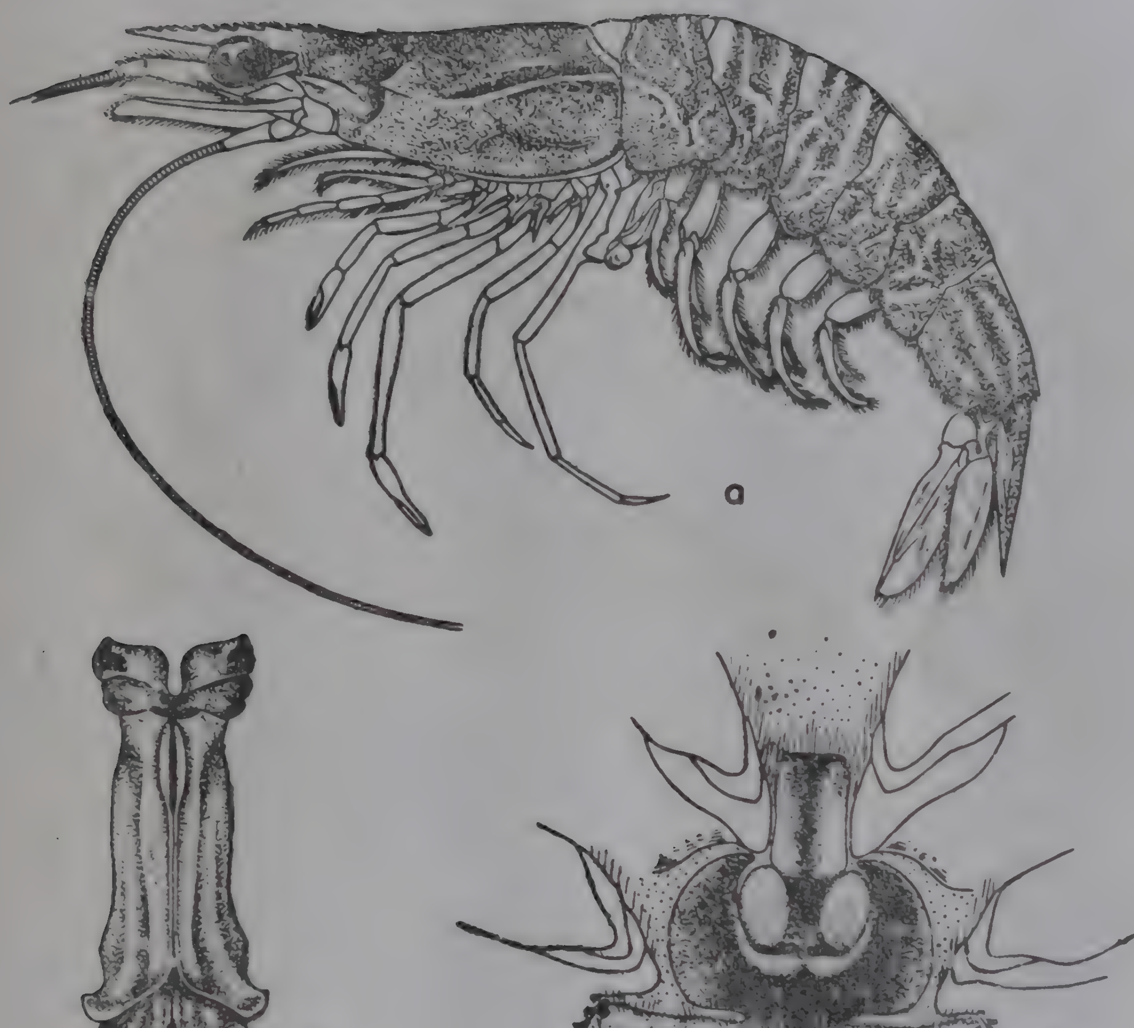

Fig. 11. a. *Metapenaeus monoceros* (Fabricius); b. Petasma; c. Thelycum

Fig. 12. Postlarva of *M. monoceros* and appendagee.

Panikkar and Iyer (1939) even suspected the possibility of the species breeding in the inside waters. Juveniles and medium sized specimens are distributed widely in the Gangetic delta area. In Bombay waters juveniles are present in the inshore areas. The adults are found to occur in slightly deeper waters of the sea. A breeding population has been located in 50-60 m depth off Cochin.

Life history

Eggs and larvae:- So far there is no work on the early larval development of the species. The first postlarva has been, however, described by Mohamed et. al.(1967) and the figures given by them are reproduced (fig.12). It has a carapace length varying from 1.104 mm to 1.112 mm and total length from 3.75 to 3.95 mm. Rostrum is small with a pair of dorsal teeth, each having a smaller spine behind, and not quite reaching middle of the eye. Antennal and hepatic spines are present. Inner branch of distal segment of antennule 2-jointed with 4 setae and outer branch faintly segmented. Flagellum of antenna 4-5 jointed and antennal scale with 26 setae. Mandibular palp jointed, distal segment with 5-6 setae. Maxillular endopod unjointed. Maxilla with 3 endites, palp unjointed and scaphognathite with 32 setae. 1st pair of pereopod with basial and ischial spines, 2nd and 3rd with basial spine only. Median dorsal spine present on the 6th abdominal segment. Distal lateral aspect of the same segment with 2 or 3 pairs of setae. Spine formula of telson 7+ 7. Due to presence of large number of brownish red chromatophores along the entire ventral aspect of the postlarva it appears brownish. This is very characteristic of the species.

The postlarval recruitment into the backwaters of Cochin has been studied in detail. Rearing of the animal from early postlarvae from about 3.0 mm in total length was also carried out in the laboratory to study early growth rate.

Nutrition and growth:- The species has an omnivorous feeding habit. The major items in the stomach contents are the remains of Crustaceans like Amphipods, Isopods and Copepods, Polychaet remains, vegetable matter like angiosperm tissues and diatoms, Foraminifera, Mollusc shell pieces

and sand particles. A slight predominance of Crustacean remains is noticed in general in a study of the stomach contents of 1173 specimens.

Results of laboratory rearing experiments on growth rates given by George (1959) are reproduced in Table X.

TABLE X

Growth rates of M. monoceros in laboratory rearing experiments

Period of experiment in months	Initial size mm	Final size mm	Increase in size mm	Rate of growth per month mm
4	3.0	33.5	30.5	7.63
4	3.0	33.0	30.0	7.50
4	3.0	34.0	31.0	7.75
4	3.0	28.0	25.0	6.25
8	3.0	60.0	57.0	7.13
4	3.5	36.0	32.5	8.13
6	3.0	46.0	43.0	7.17
4	3.5	44.5	41.0	10.25
4	3.5	43.5	40.0	10.00

The rate of growth varies between 6.25 mm and 10.25 mm from which the average growth rate works out to 7.98 mm per month. Rearing experiments conducted by him in paddy fields, however, showed a lesser growth rate of 10-15 mm during the course of 3 months in the case of juveniles. This lesser growth rate may be due to the decrease in growth rate taking place in larger specimens. But a much faster growth rate in the paddy fields was obtained by length frequency analysis of catches from paddy field fishery later. In the Gulf of Kutch area a very fast growth rate, attaining 4 inches in 5 months, has been recorded for the species.

Differential growth rate in sexes as in other species, females showing a faster growth than males, is noticed in this also. Moult frequency in laboratory reared animals as well as that of the catches from Cochin backwaters in the juvenile stages has been investigated and a total number of 32 moults during a period of growth from 3 mm to about 100 mm size recorded

Behaviour and movements:- The migration at postlarval stages to backwaters and estuaries takes place all along the coastline of India.

The presence of postlarvae in large numbers in the estuaries at Madras and other places have led to the doubt that the species is breeding in these inside waters (Panikkar & Iyer 1939, and Gnanamuthu 1966). But George (1959) shows that this is not the case and evidences from the Cochin brackwaters definitely indicate that it does not breed in the brackish waters. Here migration into the backwaters from the outside sea takes place at early postlarval stages and movement back to the sea commences after a length of about 100 mm is reached in these less saline environments in less than 1 year's time.

In the offshore trawling grounds movements of the bigger sizes into the shallower grounds from deeper waters have been noticed in the early part of the season in November. Offshore migration commences later and by about April all prawns larger than 80 mm size are found to move out of the shallow areas upto a depth of about 25 fathoms.

In the Gulf of Kutch area these prawns are found to move to deeper waters and open seas from August to November and it is believed that this movement is not for the sake of feeding but probably for spawning. Movement to deeper waters for spawning is evident in Bombay waters also.

On the east coast coast of India in the Godavari estuary the migratory movement is almost nocturnal and immigration is more during dawn. Generally the immigrant s and emigrants here are seen relatively richer on the new moon days than on full moon days. The outward migration is quite intense in the months December, May and June.

Reproduction:- As in other species this is also heterosexual. Sexes are distinguished by external genitalia, petasma and thelycum (fig. 11b&c), the development of which has been worked out by George and Rao (1967)). In the adult male in addition to the petasma the proximal end of the merus of 5th pereopod is notched, bounded anteriorly by a large hook-like spine and posteriorly by a lobule of the ischium. Although not a case of hermaphroditism, George (1963) recorded a specimen with both thelycum and petasma, the latter only partly developed.

The different stages in the maturity of females like 'immature', 'early maturing', 'late maturing', 'mature' and 'spent' have been noticed

rearely in the trawl catches off Cochin. A concentration of the species with late maturing and mature stages of gonads has been reported from 50-60 m. depths off Cochin. In Bombay waters it does not attain maturity in the inshore regions. From the studies in the backwaters of Cochin it has been proved that it does not attain maturity in the inside waters and also before 120 mm length is reached.

Mating as in other prawns is promiscuous. Fertilization is external taking place at the time of spawning. There is no information on the mating habits and fecundity.

The spawning season in Cochin waters is prolonged with two peaks, first in July-August and second in November-December. In the Gulf of Kutc area the spawning season is from February to April.

A possible spawning ground for the species at and around the sand shelves in the 50-60 m. area off Cochin was located by George & George (1964).

Metabolism - Osmotic relations:- Active regulation of chloride and osmotic behaviour of this species of penaeid prawn has been extensively studied by various authors in India. Panikkar (1948) studied this prawn in comparison with other penaeids and found that it can survive the highest salinity ranges, both low as well as high. The distribution of the species in relation to this osmoregulatory behaviour has been discussed by him. Panikkar and Viswanathan (1948) experimented on the changes in the chloride content of the blood of this species by employing the micro modification of the Volhard titration. According to them the hypotonic osmoregulation in this prawn is achieved as a result of the active regulation of the chloride ion.

Oxygen consumption as a function of size and salinity in this species from a marine as well as brackish water population was the topic of study of Rao (1958). He has noticed differences in the rate of oxygen consumption in the different media (oxygen consumption increasing with increasing hypertonicity or hypotonicity of the medium) and attributed this to the osmotic adaptation of the prawn. He found that relatively high 'b' values (regression of oxygen consumption with weight) -

obtained in natural media and that the 'b' values tend to decrease on either side of normal salinities. Comparing two natural populations of the same prawn in media of different salinities, he suggested that the pattern of response to osmotic stress in the oxygen consumption of this prawn depends on the salinity of the medium to which the animal is naturally adapted.

Reddy (1963) has shown that immediately on transfer to anisosmotic media of 5 ‰ or 35 ‰ salinity, the chloride concentration of the blood as well as the rates of heart beat, of respiration and of urine production change and these rates attain a steady level after about 8 day's stay in the anisosmotic medium. Thus these prawns become acclimatised to any medium in about 8-10 days. He also found that in prawns acclimatised to sea water of 5 ‰, 20 ‰ and 35 ‰ salinity the blood amounted to 31.65%, 28.1% and 26.2% respectively of their body weights. Gnanamuthu (1966) tried to correlate these changes with changes in body volume of the same prawn. According to him the gut of the animal is capable of altering the volume of the whole body by taking in and giving out water through the mouth and anus. He has proved that the decrease of the body volume in prawns acclimatised to dilute medium and the increase of body volume in concentrated medium, as well as the fluctuations in volume of prawns acclimatised to anisosmotic media are features associated with the part played by fluid pressure in active regulation of water across the gut wall. He is of opinion that the maintenance of osmotic equilibrium in dilute or concentrated media without any marked increase of energy expenditure is more satisfactorily explained on this basis of movement of water than of ions because the mascular action of the gut is a feature of the prawn even under isosmotic conditions.

Population and fishery

Sex ratio:- From a study of the sex ratio of the juveniles in the backwaters of Cochin during 1952-53 through 1954-55 a slightly higher percentage of females is seen in all the years, the respective percentage of females for the 3 years being 51.76, 51.08 and 51.31. In the catches of the juveniles of the species from the inshore waters of Bombay also a predominance of females over males is recorded except in the month of June.

<u>Age composition</u>:- Only the 0-year classes contribute to the backwater fishery of Cochin. In the trawl catches off Cochin 3 year classes with modal lengths 100-110 mm, 131-135 mm and 156-160 mm are recorded. The bigger year classes enter the fishery in November-December and the smaller sizes appear later. It is noted that in some years the bigger classes fail to appear in the fishery.

<u>Size composition</u>:- As in other species juveniles contribute to the estuarine and paddy field fishery. In Cochin backwaters specimens measuring more than about 100 mm in length are very scarce. The modal lengths vary from 56-60 mm to 86-90 mm. The sizes of migrating prawns of this species in the Godavari estuary ranged between length groups 11-15 mm and 91-95 mm with the modal lengths of emigrants at 46-55 mm and the immigrants showing comparatively smaller sizes.

In the inshore fishery of Bombay the sizes range in length from 40 mm to 120 mm, mostly juveniles. The adults caught in the trawl fishery off Cochin are in the size range from 90 mm to 175 mm with the modal lengths varying from 126-130 mm to 146-150 mm.

The size at first capture in the backwater fishery is 30-35 mm. The maximum size attained is 180 mm which is reached in the deeper waters.

Based on 175 observations the relationship between weight and total length is expressed by the formula

$$W = 0.01989\, L^{2.7603}$$

<u>Abundance and density</u>:- The abundance of the species in the trawl grounds off Cochin for the years 1961-62 to 1963-64 was studied in detail by George <u>et al</u>. (1968). The abundance in different depth zones was correlated to sizes in order to study the size oriented movements in and out of the zones. Generally an increase in abundance was noticed in the earlier months of the season with subsequent decline.

<u>Natality and recruitment</u>:- The recruitment of the postlarval stages into the backwaters of Cochin has been studied and the possibility of the use of this factor for predicting the subsequent fishery has been

suggested. The recruitment of these stages was also studied to determine the breeding season of the species in the area.

The reoruitment of the different year classes into the trawl fishery of Cochin was studied and itis found that bigger sizes get recruited into the fishery early in the season and smaller sizes in the latter half of the season.

Fishing gear:- In short in Bombay area the 'dol' net or bag net is the common gear used for catching prawns. In North Canana coast 'Yendi bala', a shore seine is used. On the south west coast various types of boat seines (locally called thangu vala, vatta vala, Koru vala), shore seines (Kamba vala, nona vala), drag nets (vadi vala), stake nets (ooni vala) and cast nets (Veechu vala) are employed. On the east coast stake nets, drag nets, push nets and screening traps are important in prawn fishery. In the mechanised fishery for prawns various sizes of shrimp trawls are used.

Fishing boats:- The indigenous gears are mainly operated by dugout canoes, plank built boats with outriggers and catamarans. The powered fishing boats are generally the medium sized 7 to 11 m pablo boats having 10-30 b.h.p. engines. A few larger boats with higher capacity are also operated.

Fishing areas:- Juveniles are fished in the backwaters and estuaries along the Indian coast including shallow waters and paddy fields in Kerala. The depths of these areas vary from 1 to 5 or 6 m. Adults are fished in Cochin region up to a depth of 50 to 60 metres. In Bombay waters it is fished from the inshore areas of depth range from 7 to 12 metres.

Fishing season:- On the west coast of India the seasonal pattern varies according to the type of fishery. While the species is most abundant in the backwaters of the south west coast of India in March to June and in November, the season in the trawl fishery of the coast is November-December. In the inshore fishery of the north west coast the season is in the middle of the year. The November-December season is common to the estuarine fishery of the east coast also.

In the backwater fishery of Cochin, although represented throughout the year, the species is most abundant in the months March to June and November. The percentage contribution of the species given by Menon & Raman (1961) is reproduced in Table XI.

TABLE XI

Percentage values in the monthly catches in the stake net at Cochin in 1957-58.

%	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
by no.	10.5	9.6	18.9	22.3	12.3	16.5	14.2	9.0	12.3	11.9	35.8	5.4
by wt.	21.2	21.6	32.0	36.7	33.2	35.8	29.2	27.9	36.3	28.9	63.4	17.7

The peak season for the species in the trawl fishery off Cochin is November-December. Usually it appears in the catches in small numbers by October, reaches the peak in November and disappears by the end of December. Smaller sizes are represented again in the fishery in small numbers in March-April.

In Bombay waters, although present throughout the year, the peak of the fishery is during the rainy season in July and August. The percentage contribution of this species at Sasoon Dock in 1952-53 is 7.0%.

The species is found in Chilka Lake all through the year. In Godavari estuary although present in the catches throughout the year, it is more abundant from November to May-June with peaks in November-December and May-June.

On the west coast of India there is difference in the peak season between the northern region and the southern region. Apart from the difference in the peak season, variation in the season of the species in the same locality is recorded in the trawl fishery off Cochin. November-December being the months of peak occurrence in this fishery usually, in certain years failure of the species to appear in the catches in these months has been noticed. The exact reason for the same is not yet evident. The formation of mud banks, locally called "chakara" is noticed to

influence the inshore prawn fishery in general of Malabar coast. Factors recorded to have certain influence on fishing in the backwaters of Kerala are rainfall and lunar periodicity. A direct relationship between rainfall and prawn catches have been noticed here. Also highest catches are recorded on new or fullmoon days or a day or two later. In the Godavari estuary more numbers of the species are observed in the catches on new moon days than on full moon days.

Fishing operation and results:- The effort and intensity of fishing of the species along with others in the trawl fisbery of Cochin was studied through the years 1958 to 1963 by George *et al*. (in press). They give the total catches of prawns including this species. Menon & Raman (1961) give the total catches of prawns for 1957 and 1958 for two centres in the backwaters of Kerala. Subramanyam (1965) gives the catch figures of prawns in the Godavari estuary for new moon and full moon days as well as high and low tides..

3. METAPENAEUS AFFINIS (H. MILNE EDWARDS 1837)

Common name:- In Malayalam, on the south west coast of India, the species is locally known as "kazhanthan chemmeen". In Bombay, on the north west coast, it is locally called "jinga" and in Bengal on the east coast, it is known as "chingri".

Diagnostic features:- Body tomentose; rostrum more curved, less uptilted, slightly larger than that of *M. monoceros*; not less than 9 dorsal teeth; postrostral crest does not extend to posterior part of carapace; anterolateral angles of carapace rounded; antennal spine strong, produced as salient ridge to small hepatic spine; ridge bounding well-marked post antennular groove which meets cervical groove. Anterior abdominal terga indistinctly carinated; 5th abdominal somite 2/3 length of 6th which is little shorter than telson. The telson without marginal spines and shorter than endopod of uropod.

Eyes very large, slightly surpassed by antennular scale. Upper antennular flagellum at least 3/4 length of peduncle. 3rd maxilliped barely reaches middle of antennal scale, dactylus of male not modified. Strong spines present on bases of all 3 pairs of chelipeds. Last pair of thoracic legs usually surpassing tip of antennal scale, sometimes by whole length of dactylus; no lobule on posterior edge of ischium in male, notch in the merus bounded by twisted tooth, edge of merus entire beyond tooth. No exopodite on fifth pair of legs (fig.13a).

Petasma symmetrical. In adult, 2 halves from compressed tube ending in a pair of two-lipped spouts like short horns (fig.13b).

Thelycum concave and setose. Lateral lobes fairly flat, transversely cut into unequal segments. Median plate projects between 2 lobes of the sternum between 4th pair of legs. The anterior half of this plate has a median groove (fig.13c).

The species attains a maximum length of about 180 mm.

In life body is translucent bluish green mottled with chromatophores. Uropods tipped with conspicuous green.

Distribution

General distribution:- General distribution of the species is Indian seas through Malaysia and Part of Indonesia to Hong Kong and Japan. Under the FAO distribution code (Holthuis and Rosa, 1965) it occurs in land areas 421, 423, 433, 434 and 437, and water areas ISW and ISEW, in marine and brackish waters.

In Indian waters, the juveniles of the species are found in very small numbers in the backwaters and estuaries and adults occur in the inshore waters to a depth of about 45 metres.

Differential distribution of stages:- There is no information on distribution of eggs and larvae. There are indications that the species is breeding in the inshore waters of the south west coast of India (Subrahmanyam 1967 and Rao, in press). But there does not seem to be such

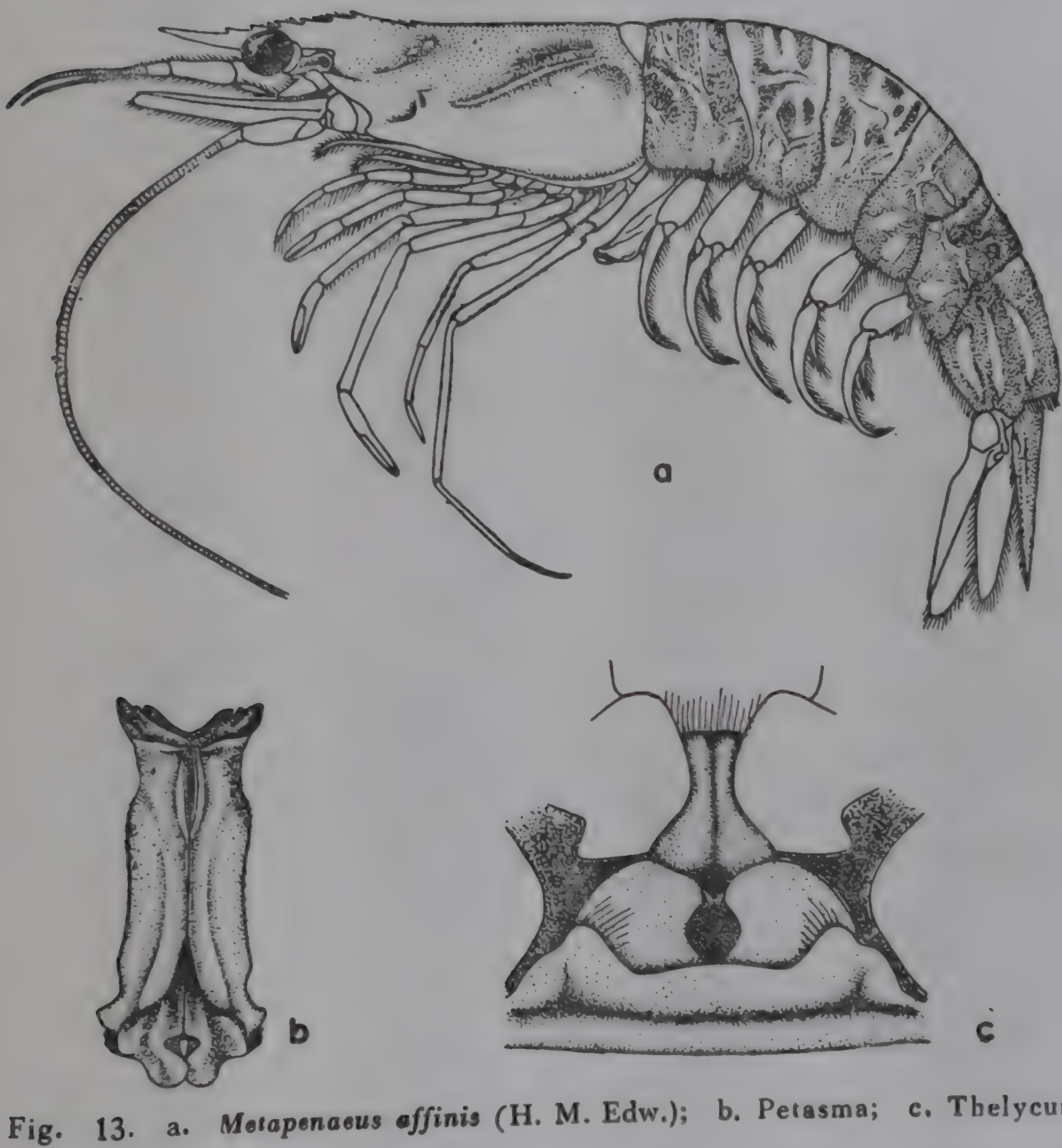

Fig. 13. a. *Metapenaeus affinis* (H. M. Edw.); b. Petasma; c. Thelycum.

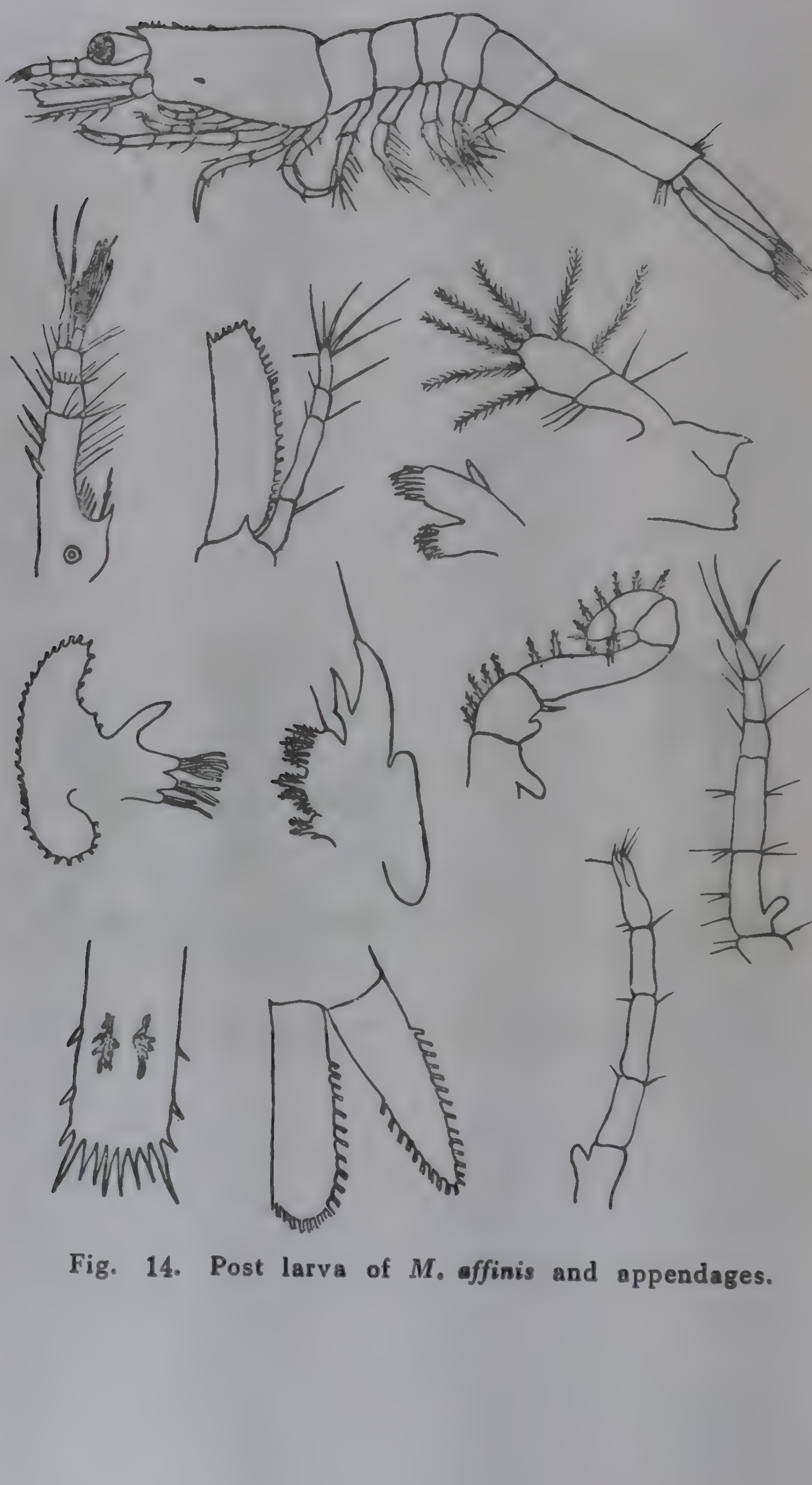

Fig. 14. Post larva of *M. affinis* and appendages.

large-scale migration of the postlarval stages into nearby estuaries as in M. dobsoni and the species never accounts for more than a small percent of the catch in the fishery for juvenile prawns in the backwaters of Cochin. In the Chilka lake and other inland waters on the east coast of India also the species is present through all the seasons.

[illegible]

Eggs and larvae:- The complete larval history of the species is not known from any Indian work. However, Hudinaga (1941) described 6 moultings in the nauplius stage, 3 in the protozoea and 3 in the mysis stage, after which the larva passes into the postlarva. The first postlarva has been described in detail recently by Mohamed et al. (1967) and their figures are reproduced in fig.14. It ranges in total length from 3.85 to 3.95 mm and carapace length from 1.168 to 1.170 mm. The rostrum is small, just projecting beyond frontal margin of carapace with 2 pairs of dorsal teeth and 1 epigastric. Antennal and hepatic spines present. Inner and outer branches of distal segment of antennule faintly jointed and with 3 setae on inner branch. Flagellum of antenna 4-jointed and with 26 setae on antennal scale. Mandibular palp jointed, distal segment with 7-8 setae. Endopod of maxilla I unjointed. Maxilla II with 3 endites, palp unjointed and scaphognathite possessing 39 setae. Unlike in the postlarva of M. monoceros there are no spines on the pereopods. Median dorsal spine present on the 6th abdominal segment. Pleopods uniramous, 3-jointed, distal segment with 10 setae. Spine formula of telson 7 + 7,posterior margin straight. Distal lateral aspect of 6th abdominal segment possess more than 3 pairs of setae. Larva does not appear brownish.

Nutrition and growth:- By analysis of the stomach contents of 30 specimens caught during daylight from the Straits of Malacca, Hall (1962) classifies the species in a group feeding mainly on vegetable matter. The items of food in their order of abundance are vegetable matter (mainly angiosperm tissue), small crustaceans (copepods and ostracods), polychaeta, echiurid setae, molluscan shell pieces and fish remains. Sand grains were present in most of the stomachs. Subrahmanyam (1967) found an omnivorous diet with preference to molluscs as the prawn grows older. Composition of stomach contents of M. affinis given by Subrahmanyam (1967) is reproduced below in table XII.

TABLE XII

The composition of the stomach contents of *M. affinis* (M. Edw.) of different sizes

Length groups (mm.)	106-110	111-115	116-120	121-125	126-130	131-135	136-140	141-145	146-150	151-155	156-160	161-165
Absolute volume of food contents ml.	0.5	0.25	0.25	0.5	0.5	0.22	0.1	0.1	0.25	0.26	0.6	0.15
Food items	%	%	%	%	%	%	%	%	%	%	%	%
Diatoms	..	..	..	..	..	..	..	..	..	8.2	..	..
Algal filaments	12.5	..	..	5.0	13.3	10.5	..	..	..	4.2	..	..
Foraminifera	31.3	..	..	..	13.3	..	..	..	..	16.7	..	..
Nematodes	9.4	20.0	40.0	5.0	1.5	2.5	..	..	...	16.7	..	..
Bivalve shells	6.2	20.0	20.0	60.0	15.0	30.5	..	..	..	33.3	..	..
Gastropod shells	12.3	..	40.0	25.0	30.0	40.0	90.5	100	80.2	..	98.0	80.0
Copepods (remains)	9.4	..	..	..	15.0	3.0	..	..	..	4.2	..	..
Crustacean appendages	0.2	..	..	..	..	5.5	..	..	10.6	12.7	..	10.3
Amphipods (remains)	..	..	..	..	..	2.5	..	..	..	4.0	..	8.2
Debris & sand particles	..	60.0	..	5.0	0.2	5.5	9.5	..	9.2	..	2.0	1.5

In Cochin trawl net catches, in the 1st year classes a growth of 20 mm in males and 25 mm among females in about 6 months time has been recorded by George *et al* (in press). According to Subrahmanyam (1967) in the coastal waters of Calicut juveniles grow up to 115 mm. Males grow up to 105 mm, 135 mm and 155 mm and females up to 115 mm, 155 mm and 175 mm respectively during the first, second and third year of their life, thus showing a differential rate of growth in the sexes, as recorded by several other authors in this as well as other species.

Behaviour and movements:- Juveniles migrate from the sea to backwaters and estuaries, but not to the same extent as some other species like M. dobsoni and Penaeus indicus. In Cochin backwaters juveniles of this species are present in very small numbers in most months. It is probable that most of the postlarvae of this species do not leave the sea.

In the offshore shrimping grounds off Cochin, some movements have been noticed. The species along with some others move to deeper waters during the monsoon period and return after the monsoon. Inshore-offshore migrations of the species in Calicut waters also show more or less the same pattern, moving shoreward from October onwards and back to deeper waters during the monsoon period May-June.

On the east coast of India in Godavari estuary there is more of emigration of the species during night. Intensive emigration takes place in April, May and June. Immigration was noticed to be most marked at dawn.

Large concentrations of this species are known to occur in shoals, along with other species, in the mud bank areas off the south west coast.

Reproduction:- M. affinis is heterosexual as are all penaeid prawns. External genitalia are petasma in male and thelycum in female (fig.13b&c). The development of these organs in the species has been described by George and Rao (1967). In addition to the petasma the adult male has other secondary sex characters as in other species.

The minimum length at maturity is 88.6 mm in the late 0-year class. By ova diameter studies and other methods the different maturity stages of the female are classified as 'immature', 'early maturing', 'late maturing', 'mature' and 'spent recovering'. In studies from Bombay waters only 3 stages, namely immature, maturing and mature stages are recorded.

Fecundity estimates show a range between 88,000 to 363,000 eggs. There is a linear logarithmic relationship between the number of eggs and the size of the prawns according to the formula

$$\text{Log } F = -0.4306 + 2.7179 \text{ Log } L$$

where F is the number of mature eggs and L total length in mm.

The spawning season in Cochin waters extends from October to March with the peak period in November-December. In the Calicut waters the season for spawning is from January to March. In Bombay coast most mature and maturing females are found in October and from April to June. The species has been recorded to spawn more than once during its growth from 91-100 mm to 151-160 mm.

On the south west coast of India in Calicut waters it is observed that the species moves to inshore areas from January to March when most of the females are mature. Along the same coast in Cochin there are indications that it breeds in the 27-45 metre areas. Further north in Bombay it prefers areas of soft mud, rich plankton and shallow coastal waters for mating and spawning.

The most highly developed ovarian eggs measure 0.352 mm according to Rao (1968 ~~in press~~). He has given measurements of various stages of maturing eggs.

Population and fishery

Sex ratio:- Menon (1957) has described in detail the sex ratio of the species from the inshore catches of the south west coast of India. The sex ratios according to him are shown in Table XIII.

TABLE XIII.

Percentage of males in total catch and the same for specimens of over 120 mm.

Year	Total catch	Over 120 mm
1952	52.2	47.2
1953	50.4	47.6
1954	52.0	39.0
1955	44.2	44.2

According to him the population of immature prawns (up to 120 mm) contains similar numbers of each sex. Among older prawns however, there

is considerable disparity, females outnumbering males by 11.6 percent. In Calicut coast (table XIV reproduced from Subrahmanyam, 1967) it is found that females invariably dominate in the catches.

TABLE XIV

Sex ratio of M. affinis in various months off Calicut coast during the years 1957-59

	June '57	July	Aug.	Jan. '58	Feb.	Mar.	Apr.	May	June	July	Aug.	Jan. '59	Feb.
Males	47.4	49.9	42.9	46.5	40.0	47.2	43.3	48.4	38.7	43.8	46.4	32.5	47.7
Females	52.6	50.1	57.1	53.5	60.0	52.8	56.7	51.6	61.3	56.2	53.6	67.5	52.3

Statistical analysis of the data on sex ratios of the species in the offshore trawl fishery off Cochin showed that, unlike other co-existing species the two sexes were present in similar numbers throughout the year. Any migration from these grounds must therefore involve similar numbers of each sex. In Bombay waters females occur in more numbers throughout the year, especially during the months of October, November and December.

Age composition:- In the inshore and offshore fisheries off Cochin the species is mostly represented by the 1st and 2nd year classes. In the trawl fishery the 2nd year class generally enters the fishery in the earlier half of the season and the first year class in the latter half. The late 0-year class is also represented in the inshore fishery in some months. In the backwater fishery only the 0-year class is represented. Three year groups are present in the fishery at Calicut also. The lengths attained during the three years are 105 mm, 135 mm and 155 mm in males and 115 mm and 175 mm in females respectively.

Size composition:- In the inshore fishery of the south west coast of India the prominent length groups are 71-75 mm and 81-85 mm in February to April. In November and December the prominent groups are 121-125 mm and 126-130 mm. In some years the mode reaches 136-140 mm in January or February.

In the trawl fishery, from October to January larger sizes, with lengths between 121 and 140 mm are represented in more numbers than in the inshore fishery. Towards the middle of the season, i.e. after February, smaller sizes between 111-115 mm come into the fishery. In the Bombay fishery the species ranged in size from 45 mm to 156 mm in length.

In Calicut waters during the period June to August the prawns of this species present in the catches are juveniles measuring below 120 mm, with the modes at 56-60 mm in June and 91-95 mm in August. In other months more than one year class are represented in the collections, in the length range from 31 to 170 mm. Three distinct modal groups are found at 96-100 mm, 141-145 mm and 156-170 mm and these are found to shift in later months.

The size at first caputre in the backwaters is 30-35 mm as in *M. monoceros*. The maximum size attained in the brackishwaters is about 120 mm and that in deeper waters of the sea nears 180 mm.

Length weight relationship is given by Subrahmanyam (1967) using the measurements of 625 specimens ranging from 31 mm to 176 mm in length. He related weight and total length by the formula

$$W = - 4.6873 + \log L^{2.7867}$$

Based on 183 observations Hall (1962) had given the formula as

$$W = 0.7079\ C^{2.770} \quad \text{where C is carapace length.}$$

Abundance and density:- Depthwise abundance of the species in the shrimping grounds off Cochin was studied in detail by George *et al.* (1968). There is a general steady increase in abundance in the first half of the season with subsequent decrease. There is considerable decline in abundance of the species in Calicut waters during the months June and July.

Natality and recruitment:- In the inshore fishery of Cochin recruitment of bigger sizes into the fishery commences in October. After December-January the smaller specimens get recruited into the fishery. In the offshore trawl fishery also more or less the same pattern is observed. Recruitment of postlarvae into the backwaters is on a small scale compared to other species.

Fishing areas:- The species is fished particularly on the west coast. Juveniles are fished in small numbers in the backwaters and estuaries including paddy fields of the west coast of India in shallow waters ranging from 1 to 5 metres.

Young adults and adults are caught from depths up to about 55 metres, from the sea. In the trawl fishery off Cochin a concentration of the species is reported in the 18-20 metre depth region. The depth from which it is caught in large numbers from Bombay range from 7 to 13 meters.

Fishing seasons:- The fishery of *M. affinis* tends to be seasonal in all areas where it occurs, but the periods of peak abundance vary in the different fisheries. Inthe backwater fishery of Cochin the species is most abundant from January to June. The percentage contribution of the species given by Menon & Raman (1961) is shown in Table XV.

TABLE XV

Percentage values (numerical and by weight) of *M. affinis* in the monthly catches in the stake net at Cochin from February 1957 to January 1958

Months	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.
By weight	9.5	10.3	9.9	5.9	12.7	0.5	..	..	2.5	1.4	5.9	13.4
By number	11.4	15.3	15.3	11.4	16.9	2.1	2.1	0.4	1.6	5.2	6.9	15.8

George (1961) gives the percentage contribution of the species in the inshore fishery of the south west coast of India for 1956 through 1960. Its highest percentage is reached in the post monsoon months, November and December, and it is fished from October to May. Subrahmanyam (1967) gives percentages of the species in departmental catches as well as commercial fishery at Calicut during the years 1957-59, reproduced in Table XVI.

TABLE XVI

Abundance of M. affinis in the departmental collections and commercial fishery at Calicut during the years 1957-59.

Year	Month	Departmental collections: Percentage of prawns	Departmental collections: Percentage of M. affinis	Commercial fishery: Percentage of prawns	Commercial fishery: Percentage of M. affinis
1957	January	4.00	1.20	0.10	..
	February	41.52	3.80	0.10	..
	March	43.23	4.60	18.10	..
	April	50.02	6.40	9.53	..
	May	46.67	..	41.65	0.52
	June	..	..	19.47	0.62
	July	60.86	1.40	25.30	1.32
	August	12.85	10.20	0.81	4.56
	September	30.04	..	0.05	..
	October	0.44	..	..	..
	November	15.62	..	..	..
	December	32.83	..	..	..
1958	January	47.05	1.94	0.24	..
	February	28.38	4.49	0.30	0.23
	March	24.37	5.75	2.29	..
	April	37.14	8.11	1.88	..
	May	43.52	2.10	1.16	..
	June	..	..	0.23	2.23
	July	9.77	0.31	17.77	..
	August	7.69	14.36	14.44	..
	September	5.60	..	11.79	..
	October	..	..	0.09	..
	November	0.11	..	0.08	..
	December	2.17	..	..	..
1959	January	3.57	28.57	..	..
	February	12.00	13.99	..	..

The percentage is very low in May to July period.

The peak season for the species in the trawl fishery off Cochin is from December to February. In Bombay waters, although it is available throughout the year, it is most plentiful from January to March. In 1952 to 1954 the species formed 12.3 percent of the Bombay prawn catch. In Calicut inshore waters the fishing season is January to August. On the east coast in the Godavari estuary, although present most of the year, it is more abundant from November to May.

The inshore fishery of the Kerala coast intensifies after the annual formation of mud banks on which the prawns concentrate. The fishery in the backwaters of Kerala is probably influenced by rainfall and lunar periodicity. On the Calicut coast there has been found a correlation between bottom salinity and abundance of the species, the fluctuations in the two following a similar pattern. In Godavari estuary also a positive relationship between bottom salinity and abundance of the species was found.

Fishing operation and results:- George (1961), studying the prawn fishery of three centres of the Kerala coast for the years 1956 through 1960, used the total effort and intensity of fishing and established a relationship between catch-per-man-hour and recruit sizes. In the trawl catches of Cochin George *et al.* (in press) studied the effort and intensity of fishing through the years 1958 to 1963 and concluded that there is no overfishing in the area. The catch and effort for one season is shown in Table XVII.

TABLE XVII

Total catch and catch per hour of *M. affinis* in the trawl catches for the season 1959-60

Year	Month	Percentage by weight	Total catch prawns in kg.	Total effort in hrs.	Catch of *M. affinis*	Catch per hour for all prawns	Catch per hour for *M. affinis*
1959	November	20.8	2306	301.17	479	8.0	1.6
	December	28.9	10027	430.00	2898	23.0	6.7
1960	January	49.6	22725	491.25	11272	46.0	22.9
	February	28.3	50113	692.68	14182	72.0	20.5
	March	55.8	14119	608.75	7878	23.0	12.9
	April	20.8	18944	660.42	3940	29.0	6.0
	May	29.2	20712	387.33	6048	54.0	15.6

Total catches of prawns including this species for certain regions are given by some authors. Subramanyam (1965) gives the total catches of this and other species for new moon and full moon periods in the Godavari estuarine system on the east coast of India. High tide and low tide catches are also given by him.

4. METAPENAEUS BREVICORNIS (H. MILNE EDWARDS 1837)

Common names:- In the Gangetic delta area and in Calcutta market it is called 'dhanbone chingri'. Along Pakistan coast it is known by different names like 'honyi', 'koraney', 'kucho' and 'saga' chingri.

Diagnostic features:- Body not, or very little, toméntose. The rostrum is curved and rarely reaches to the middle of the 2nd joint of the antennular peduncle, sometimes only just surpassing the eyes, with a decided crest and dorsally bearing 7 teeth. The post-rostral crest, however, is very indistinct and only just reaches to the posterior third of the carapace. The antennal spine is weak and not continued as a well-cut post-antennular ridge, so that the post-antennular groove is shallow. The hepatic spine is very small. The sub-hepatic groove (anterior part of cervical groove) which defines the branchial region anteriorly, is shallow and does not meet the hepatic spine. The ridge defining the branchial region superiorly is present only in the posterior part of the carapace, and even there it is indistinct (fig.15a).

Median carination on abdominal terga present from 4th segment, that of 3rd hardly perceptible and that of 4th only in posterior two-thirds. The 5th abdominal somite about 2/3 length of the 6th, which is as long as the telson. The telson shorter than the inner caudal swimmeret and has no marginal spines. Racek & Dall (1965) observe a pair of clearly perceptible distal spine and a series of minute spinules on the telson.

The outer antennular flagellum is nearly as long as the peduncle.

3rd maxillipeds barely reach the middle of the antennal scale; their dactylus in the male not modified, but consists of a slender, setose, ~~taep~~ tapering joint about 4/5 length of the propodite with which it articulates end-on.

There is a strong antrose spine on the basis of all three pairs of chelipeds. Ischial spine present on 1st pereopod. The last pair of

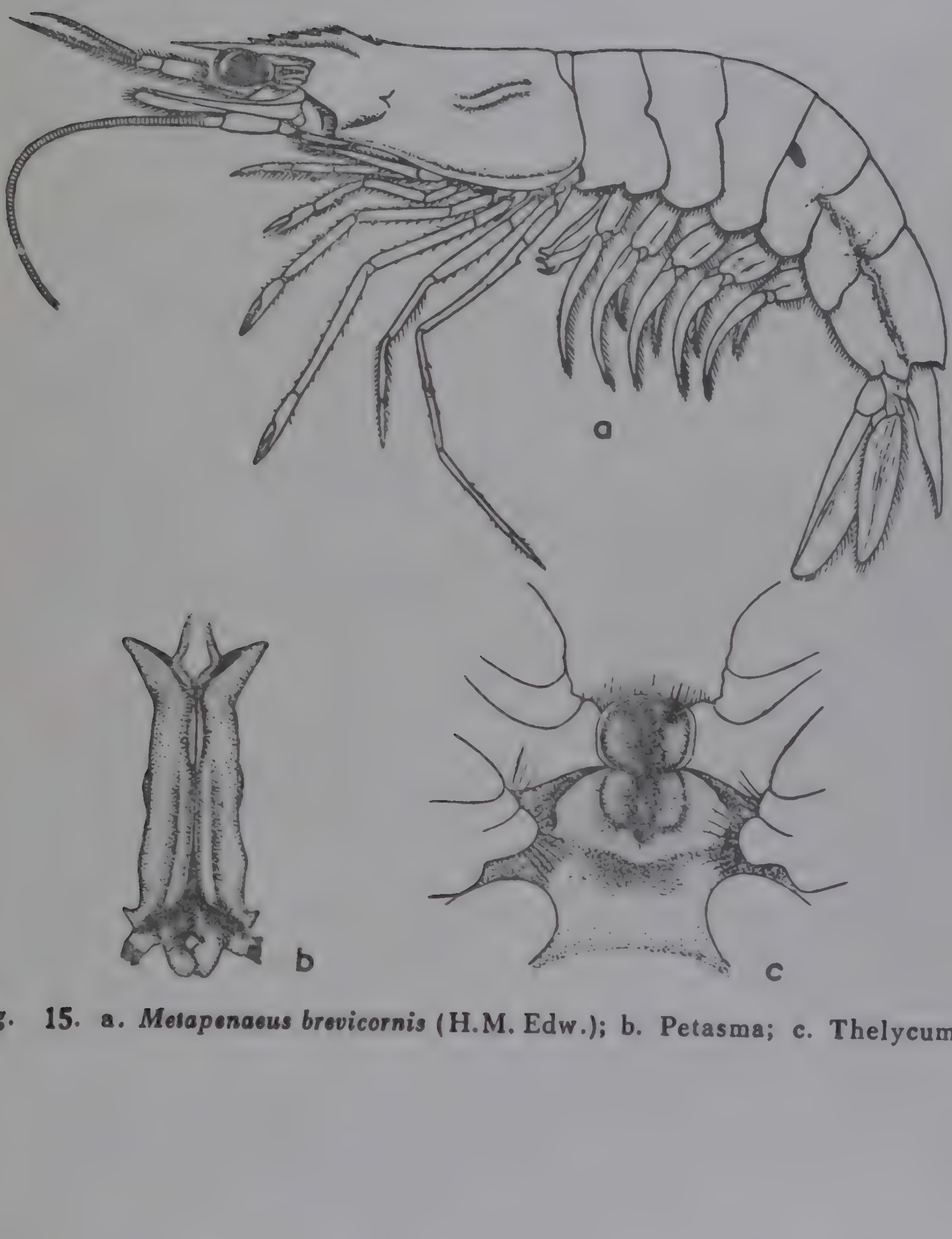

Fig. 15. a. *Metapenaeus brevicornis* (H.M. Edw.); b. Petasma; c. Thelycum.

thoracic legs reach more than a dactylus length beyond the tip of the antennal scale. In the adult male there is notch in the posterior border of the merus at its proximal end, the noth being bounded by a small tooth (not a spine) beyond which there are no denticles; nor is there any sub-termial lobe on the border of the ischium.

The petasma is symmetrical and consists of two halves lightly folded in all their length, interlocked all along their anterior margin and in close apposition along a great part of their posterior margin so as to form a compressed tube. Distally this tube ends in a pair of simple spouts, each of which carries near its middle a longish filament (fig.15b).

The thelycum (fig.15c) is concave; its median lobe is shaped like a figure of eight, the anterior portion being embraced between processes of the antepenultimate thoracic sternum, the posterior portion being embraced by the flat crescent-shaped lateral lobes.

The species attains a maximum length of about 140 mm.

Body flesh coloured with sparsely distributed brown dots, especially on the dorsal aspect. More such dots on the telson and uropods.

Distribution

General distribution:- The general distribution of the species is West Pakistan through Indian, Malaysian, Thai and Indonesian waters to about East Borneo. Under the FAO distribution code (Holthuis and Rosa 1965) the distribution in land areas is in 421, 423, 424, 425, 431, 432, 433 and 434. In water areas it has a distribution in the regions ISW and ISEW.

In the distribution of the species in Indian waters one difference noticed from other species like *M. monoceros* and *M. affinis* is that this does not occur in the southern area, but contributes to good fishery in the northern region both on the west as well as east coasts. Well represented in estuaries and inshore waters, especially in the east coast. In estuaries more juveniles are met with. In the Gulf of Kutch area the species is mostly distributed in areas with sandy bottom.

estuary by tidal action, where they live until the attainment of maturity. Adults appear to migrate back to the lower reaches of the estuary where they mature and spawn.

In Bombay waters it appears that the females are migrating away from the inshore areas towards deeper zones.

Immigration and emigration of the species in and out of the Godavari estuary has also been studied.

Reproduction:- As in the case of other species of penaeids it is heterosexual. Externally visible genitalia and secondary sex characters are present. The size at which the petasmal endopodites fuse in 50% of the specimens is 1.12 cm carapace length as determined by Hall (1962).

Based on the rapid decline and recovery in the condition factor with the attainment of sexual maturity Rajyalakshmi (1961) concludes that the species attains maturity at about 100 mm total length. Bhimachar (1964) records the age at maturity as 2 years and size 75.0 mm.

Females with conjugal pads are present in the inshore waters of Bombay, but mature specimens are absent in the same area indicating that females move to deeper waters for spawning after mating in shallow regions. In Hooghly mature individuals are found to move from the upper reaches to the lower reaches of the estuary for spawning.

In this estuary the species is reported to have two spawning seasons, one in the early summer, namely, March-April and the other in the monsoon months July-August.

Population and fishery

Sex ratio:- In Bombay waters on the west coast of India females are predominant in the catches throughout the year except in the months January-February. On the east coast in the Hooghly estuary there are more of females in all the months of the year. The ratio of males to females during all the months combined was found to be 1:1.2. The female percentages of these two areas are given in table XIX.

TABLE XIX

Monthly percentage of females

Place	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Bombay 1952-53 (Shaikmahmud & Tembe, 1960)	49.0	50.0	57.0	67.0	65.0	63.0	57.0	55.0	56.0	58.0	59.0	56.0
Hooghly estuary 1959-60 (Rajyalakshmi, 1961)	61.4	56.0	54.0	56.4	54.0	55.0	51.5	53.8	54.3	52.2	53.7	57.6

Age composition:- Modal lengths of age groups of the species estimated by length-frequency analysis of samples from Hooghly estuarine system given by Rajyalakshmi (1961) are shown in Table XX.

TABLE XX

Modal lengths of different age-groups of *M. brevicornis* as estimated by length-frequency analysis of samples from commercial catches of Hooghly, Matlah and Roopnarain estuaries.

Calender year	Males					Females				
	0	I		II		0	I		II	
		Monsoon brood	Summer brood	Monsoon brood	Summer brood		Monsoon brood	Summer brood	Monsoon brood	Summer brood
1959	26.8 ±3.8	40.0 ±5.6	54.5 ±7.3	69.0 ±4.6	82.0 ±4.3	24.5 ±9.1	36.8 ±4.8	52.1 ±7.7	71.0 ±5.6	90.5 ±6.3
1960	24.8 ±3.7	37.2 ±4.6	49.6 ±5.8	66.0 ±3.5	79.0 ±4.97	26.0 ±2.9	38.0 ±5.5	52.8 ±5.3	72.5 ±4.4	87.5 ±5.7
Average	25.8	38.6	52.05	67.5	80.5	25.25	37.4	52.45	71.75	89.0

In the lower reaches of upper zone and upper reaches of middle zone of Hooghly estuary I and II year groups form the fishery, the I year class forming the dominant group during all the months except August to October.

In the lower middle zone and lower zone two additional age groups 0 and III also contribute to the fishery, the 0 year group appearing only during the period July to December.

Size composition:- In the Hooghly estuary the catches ranged in size between 15 mm and 115 mm. The length frequency histograms for females and males separately are given by Rajyalakshmi (op.cit.) for the years 1959 and 1960. Males and females measure about 45.8 mm and 47.4 mm respectively by 1 year and 80.5 mm and 89.0 mm by 2 years and these sizes contribute to the fishery in the upper and middle zones of the estuary. The III year group measuring about 90.0 mm also contribute to the fishery in the lower reaches.

In the inshore fishery for the species in Bombay water sizes ranging from 40 mm to 110 mm length are observed.

The length-weight relationship was worked out by Rajyalakshmi (op. cit.) for individuals ranging in total length from 23 mm to 120 mm on the basis of 1,968 observations from the Hooghly estuary. She noticed that the relationship between length and weight for the species is linear in the logarithmic form and that the relationship is different for the 0 year group (a) and other individuals (b). The formula for the two groups were:

$$\text{(a)}\ \log W = -\ 5.0083 + 2.9810 \log L$$
$$\text{(b)}\ \log W = -\ 4.5407 + 2.6976 \log L$$

She also studied the relative condition factor 'Kn' which is a ratio between observed and smoothed mean weight ($W/\hat{W}$). Seasonal fluctuations and variations in different size groups have been observed in the condition factors and this has been attributed to the nature of growth pattern.

Based on 70 observations Hall (1962) recorded the relationship between carapace length and weight, which is expressed by the formula $W = 0.8630\ C^{2.650}$

Abundance and density:- In the Hooghly estuarine system *M. brevicornis* contributes to over 30.0% of the total prawn catches.

Natality and recruitment:- Based on the availability of smallest modal sizes in the catches the main recruitment season appear to be July-August.

Mortality:- No information available.

Fishing gear:- Bag nets ('bhinjals' and 'thorjals') form the main type of gear with which these prawns are caught in the Hooghly estuarine system. Catches by these nets account for nearly 90% of the total catches. Small drag nets and dip nets account for the rest of the landings. The species is also caught in barrier nets ('kalpat jals'). The 'behundi jal' mentioned by Chopra (1939) is another bag net or conical purse net operated in Bengal in which the species is caught.

Along the Bombay coast the 'dol net' or bag net and a smaller type of the same 'bokshi' are the main gear used for catching the species along with other prawns and fishes.

Fishing boats:- Most of the operations of the above nets are carried out without the help of boats. In operations in which boats are used it is the dug out canoe which are employed.

Fishing areas:- In Bombay waters these prawns are caught from inshore waters varying in depths from 4 to 7 fathoms. In the Hooghly estuarine system they occur in shallow waters.

Fishing season:- July to February is the main season for the species in the Gulf of Kutch area. Slightly south of this area, on the Bombay coast, although the species is found throughout the year, the peak season is from January to March.

In the Hooghly estuarine system it is fished almost round the year. In the lower zone of Hooghly and lower Sunderbans the bulk of the landings is during the winter months of November to February. In the Matlah estuary the fishery commences in August and continues up to March.

According to Rajyalakshmi (op. cit.) the trend of occurrence suggests that the bigger sizes are more or less confined to areas of higher salinity. Thus salinity and other hydrographic features of the environment play an important part in influencing the seasonal distribution of the species in the Hooghly estuarine system.

Fishing operation and results:- In Godavari estuary on the east coast Subrahmanyam (1965) gives details of catches of prawns including this species during different lunar phases and also at different tides.

V GENUS *PARAPENAEOPSIS* ALCOCK 1901

By

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V GENUS PARAPENAEOPSIS ALCOCK 1901

P. Vedavyasa Rao

Genus Parapenaeopsis comprising sixteen valid species enjoys a wide distribution. Majority of the species are restricted to tropical and warm temperate shallow seas, but a few of them are also recorded from brackish water regions. Most of the species are found in the Indo-Pacific region, from Persian Gulf and east coast of Africa to Japan and Australia. A couple of species also occur from Eastern Atlantic and Pacific America. Seven species are recorded from the Indian region so far. These are, 1. Parapenaeopsis uncta (Alcock), 2. P. cornuta maxillipedo Alcock, 3. P. nana (Alcock), 4. P. acclivirostris (Alcock), 5. P. sculptilis (Heller), 6. P. hardwickii (Miers) and 7. P. stylifera (H. Milne-Edwards).

Holthuis and Rosa (1965) have listed ten species as of economic value, but only five of them viz., P. stylifera, P. sculptilis, P. hardwickii, P. hungerfordi and P. tenella are abundant in various regions. In India, the first three species are commercially exploited and the salient features of their biology and fisheries are presented in the following chapters.

1. PARAPENAEOPSIS STYLIFERA (H. MILNE EDWARDS, 1837)

The species was first described by H. Milne-Edwards in 1837 in 'Histoire naturelle des Crustaces'. The diagnostic characters of the species are as follows.

Rostrum sigmoid with a proximal crest bearing 5-7 teeth + epigastric, the distal portion styliform and edentate, strongly upcurved, projecting much beyond the tip of antennular peduncle. Adrostral carina ending about halfway between epigastric and penultimate tooth; sulcus shallow. Postrostral carina distinct almost extending to posterior border of carapace which is finely puncuate and with fine longitudinal suture running

from orbit to the gastric region, a similar short transverse suture extends across the branchiostegite at the level of the 3rd pair of legs(Fig. 16A).

Orbital spine small, postocular sulcus moderately deep at angle 45° to rostrum. Cervical sulcus shallow and short, not quite reaching longitudinal suture. Antennal spine prominent, antennal carina ending below hepatic spine. Hepatic sulcus pronounced, sinous attaining horizontal position in its anterior $\frac{1}{4}$; hepatic carina distinct only for lower $\frac{1}{2}$ sulcus commencing from below hepatic spine and reaching to the sharp pterygostomian angle.

Antennular flagella slightly longer than carapace in both sexes and subequal.

Third maxilliped surpassing carpocerite by dactyl; 1st pereopod reaching to the base of carpocerite, 2nd to tip of carpocerite; 3rd exceeding carpocerite by chela; 4th slightly exceeding carpocerite; 5th reaching almost tip of 2nd antennular segment. Mastigobranchiae and basial spines on first two pereopods.

Abdominal carination beginning from posterior 1/3 of 3rd somite, carina on 6th ending in a sharp spine. A pair of lateral cicatrices on 6th abdominal somite only. Telson with 2 or more than 2 pairs of conspicuous subapical fixed spines.

The petasma (Fig.16 B) symmetrical, simple and tubular; the distolateral projections slender, horn-like and straight, directed anterolaterally at 45° to petasmal axis, with ventral openings; distomedian projections small and curved ventrally. Proximal lateral enlargements of petasma of moderate size and evenly rounded.

The thelycum (Fig.16 C) consists of a large concave and square anterior median plate, posterior extension a slender stem-like process. Lateral plates smaller, fused posteriorly, each with an anteromedian indentation corresponding to a knob-like posterior process of the anterior lobe.

Colour:- The upper part of the body of the species is brownish green the sides and the appendages are scarlet in life.

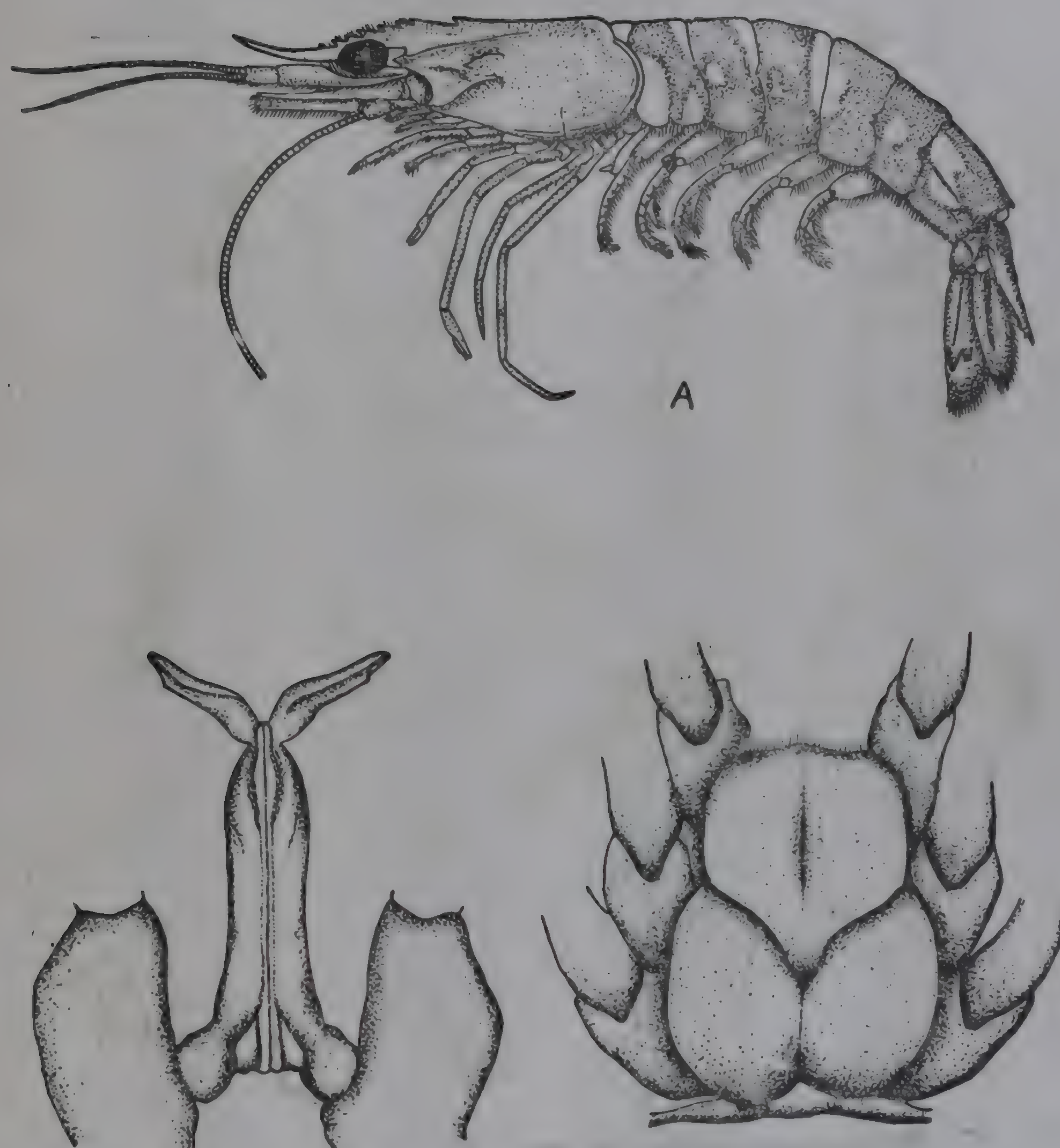

Fig. 16. *Parapenaeopsis stylifera* (H. Milne-Edwards)
A. An adult male, B. Petasma, C. Thelycum.

Fig. 17. *Parapenaeopsis stylifera* (H. Milne-Edwards), first postlarva.
a. Lateral view, b. antennule, c. Antenna, d. Mandible, e. Maxilla I, f. Maxilla II, g. Maxilliped I, h. Maxilliped II, i. Maxilliped III. j. First pereopod, k. Telson, l. Uropod (Mohamed *et al.*, 1967)

Although the specific status of *P. stylifera* is well established, diverse opinion exist regarding the position of its variety, *P. s. coromandelica* created by Alcock (1906). Thus, Hall (1962) considered the difference in telsonic armature of the variety from true *P. stylifera* as sufficient for specific discrimination and raised the variety to specific rank, while Racek and Dall (1965) disagreeing for this separation opined that these two forms represent distinct and geographically separated races and it is necessary to retain their taxonomic distinction at an infraspecific level. But, the extension of its geographical distribution to the west coast of India and their occurrence along with *P. stylifera* in appreciable numbers prompted George to synonymise the variety with *P. stylifera*.

This prawn is locally called in Malayalam as 'Karikadi Chemmeen' on the southwest coast of India and in West Pakistan as 'Kiddi'.

Distribution

Unlike a number of other penaeids that migrate into estuarine regions when quite young, *P. stylifera* is purely a marine species spending all its life in sea. The general distribution of the species is from West Pakistan, coasts of India, East Pakistan through Malaysian waters to Indonesia. It inhabits comparatively shallow coastal waters up to 30-40 mètres depth. The commercial concentration of the species outside the Indian region has been reported from the sea off Mutwal, Negombo and Chilaw (Ceylon) at depths of 7 to 10 metres (De Bruin, 1965); Alor Star area (Northwestern Malaysian coast) Penang (Hall, 1962); Tjilatjap (Java), Padang (Sumatra) and Eastern Borneo (Kalimantan) (Racek and Dall, 1965). A study of their relative abundance of distribution through the coastal regions of India shows striking difference. They are most abundant from Veraval to Trivandrum coast, but moderately available in the Sind, Mekran and Kutch areas. In the southern most part of west coast of India and in the east coast they are found only in lesser numbers. It occurs all the year round in the west coast of India, but abounds the shallow inshore waters from January to June and deeper waters in September-October. Their occurrence in the marine region and their relative abundance during warmer months seems to be due to their inability to tolerate lesser salinity.

Life history

Eggs and larvae:- Very little information is available on the distribution of eggs and larval stages. Menon (1953) believes that the eggs are liberated in the shallow waters at a depth of 18-23 metres and the larvae occur from October to March in the Malabar coast. The eggs of the species were also collected from the inshore waters of Cochin and the early larval stages like protozoea and zoea occur throughout the year except during June to September. The first postlarval stage (Fig.17) measures from 4.25 to 4.75 mm in total length and 1.290 to 1.315 mm in carapace length. The larva is characterised by having a small rostrum reaching middle of eye with 2 dorsal and one epigastric teeth; carpace with antennal, hepatic and branchiostegal spines; inner branch of distal segment of antennular peduncle 5 jointed with 6 setae at tip, outer branch 3 jointed; antennal flagellum 10 joined and the scale with 39 setae; mandibular palp jointed; 2nd maxilla with 4 endites and the scaphognathite bearing 54-55 setae; abdominal segments without median dorsal spines and the telson with 3 pairs of lateral and 11 posterior spines, the median posterior spine being very large and about equal in length to the large outermost pair of posterior spines, the margin of telson tapering between posterolateral spines. The larva has light brownish pigments at the tip of antennular peduncle, but the eye stalks are yellowish. A few branched brownish chromatophores are present in the middle region of the carapace. Abdomen appears yellowish and the posterior portion of the 6th abdominal segment and the basal portion of uropod are tinged with yellowish and brownish pigments. Tip of telson is light brown in colour (Mohamed et al. 1967).

The swimming behaviour of the larva observed in the laboratory has shown that the larva swims straight forward without any jerk and rests horizontally at the edges of the container.

A study of the distribution and abundance of these larval stages in the inshore and backwater regions of Cochin has revealed that these larvae do not enter the backwaters and the scarcity of postlarvae in the inshore waters appears to be due to their preference of more saline deeper waters.

Food and feeding:- Generally penaeid prawns feed at the bottom. Available information on the food and feeding habits of the species is restricted to a study of the kinds of food items observed from the gut contents of dead specimens. Very little work has been done on the nutritional aspects of the food or the selectivity and food preferences of these prawns. Menon (*op. cit.*) examined the stomach contents of prawns varying in size from 45 to 105 mm. The species feeds mainly on crustaceans belonging to various orders like copepods, cirripeds (Cypris larvae), mysids, amphipods and larval decapods. Minute gastropods, bivalves and foraminifera are also recorded in the stomach content frequently. An interesting feature is that unlike in the associated penaeid prawns of the locality, vegetable matter other than the diatoms has been noticed rarely. Since they feed at bottom considerable amount of sand and mud are also present in the stomach content.

Hall (1962) examined the stomach content of 30 specimens of his '*P. coramandelica*' taken from the Alor Star fishery and ranging in carapace length of 1.0 to 2.1 cm. Most of the stomachs were full. The important food items in the diet were as follows.

Item	Predominant	Residual	Total
Polychaeta	-	2	2
Small crustacea	14	14 x	28
Large crustacea	3	-	3
Mollusca	8	5	13
Pisces	-	2	2
Vegetable	5	13	18

Small crustacean material consisting of Calanoid and Harpacticoid copepods was present in considerable numbers. Antennal debris formed the bulk of large crustaceans. The molluscan material appeared to consist of mainly a protobranch lamellibranch having a thin iridescent shell. All the vegetable material was angiosperm tissue. Detritus formed only a very small part of the stomach contents, but the diatom, *Coscinodiscus* (? *Concinnus*) was relatively numerous in the stomachs of this species.

Penaeids in general are considered as detritus feeders (Panikkar and Menon, 1956), taking both animal and plant that accumulate at the bottom of their habitat. But Hall observes that detritus can be

considered only as a minor item of diet and many penaeids appear to feed on that which is most readily available and some species even select the food. Thus he classified the species embraced in his studies into 6 groups based on their feeding habits, and his '*P. coramandelica*' was included in that group of species which feed mainly on small crustaceans.

Growth:- As in other crustaceans, the growth takes place by resorting to periodical ecdysis. The estimation of growth becomes difficult due to this phenomenon and the absence of any hard parts in the body. All the studies made so far regarding the growth of these prawns were based on tracing the progression of modes in size frequency distribution. Menon (*op. cit.*) studying the growth process of the species from Malabar coast observed that the postlarval prawns ranging in size from 10 to 20 mm were present in all months from December to June. In November and December most of the prawns were measuring above 60 mm. (Fig.18) and he believed that the juveniles caught during the latter month were belonging to the generation produced in two preceding months. The frequency curve showed two generations the one year class at a modal length of 80-90 mm and 0 year group without any well defined modes. The subsequent growth of 0 year group was estimated from the frequency curve of the succeeeding months. The rapidly growing 0 year group attained 70-80 mm by March and the one year class prawns were dwindling due to fishery and by June the large sized prawns disappear from the inshore waters probably due to migration to deeper waters at the commencement of southwest monsoon. From these observations he concluded that the prawns born probably towards close of October or early in November grow to a length of 70-80 mm in the course of 4-5 months and they grow faster during this period. The subsequent growth from April to October becomes slow and one year prawn attain an average length of 90-100 mm.

In the trawl fishery of Cochin (George, *et al.*, in press) the dominant mode of the species in November was 81-85 mm in males and 86-90 mm in females. These modes shifted gradually to 96-100 mm and 106-110 mm respectively by middle of the season in February-March. The growth in the intervening period of 4 months works out to 15 mm for males and 20 mm for females.

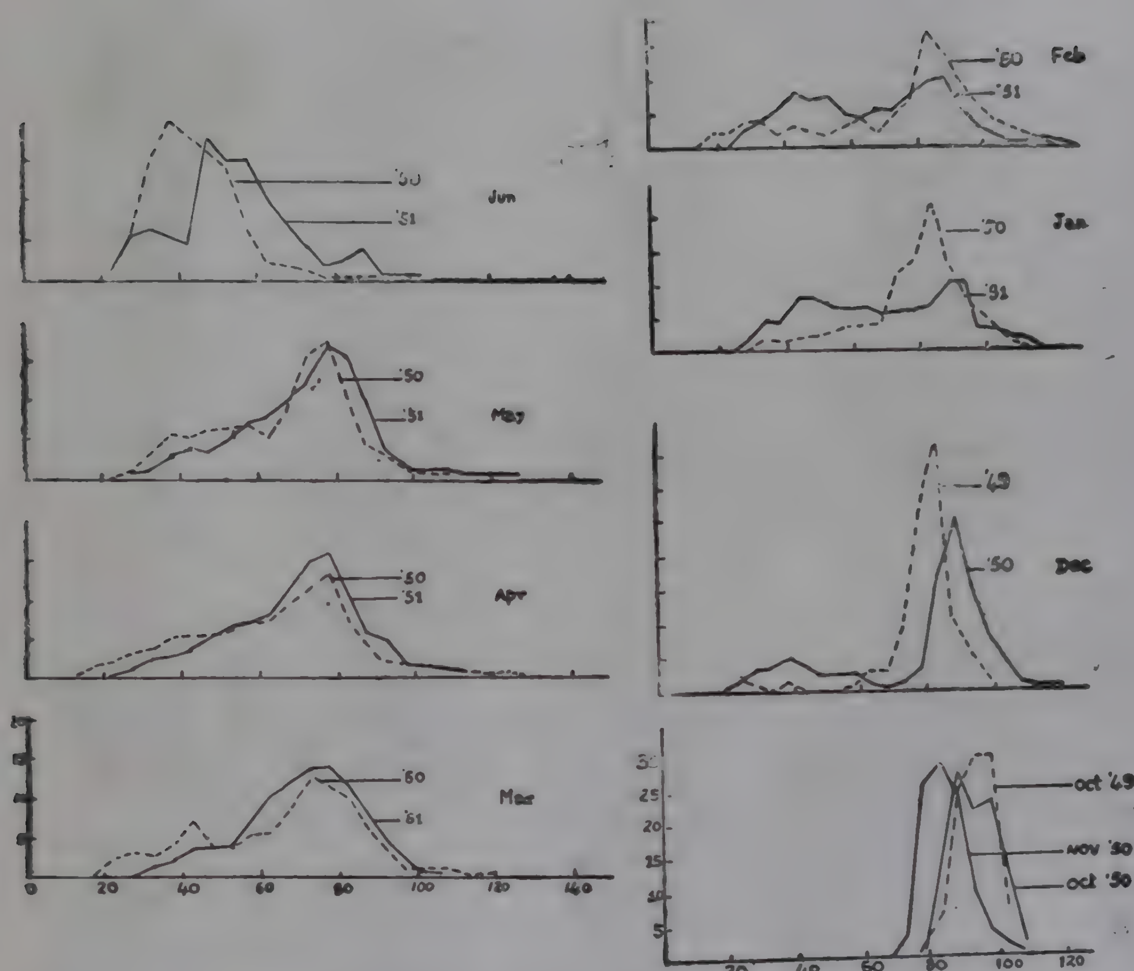

Fig. 18. *Parapenaeopsis stylifera* (H. Milne-Edwards), Length frequency distribution (of both sexes) (Menon, 1953)

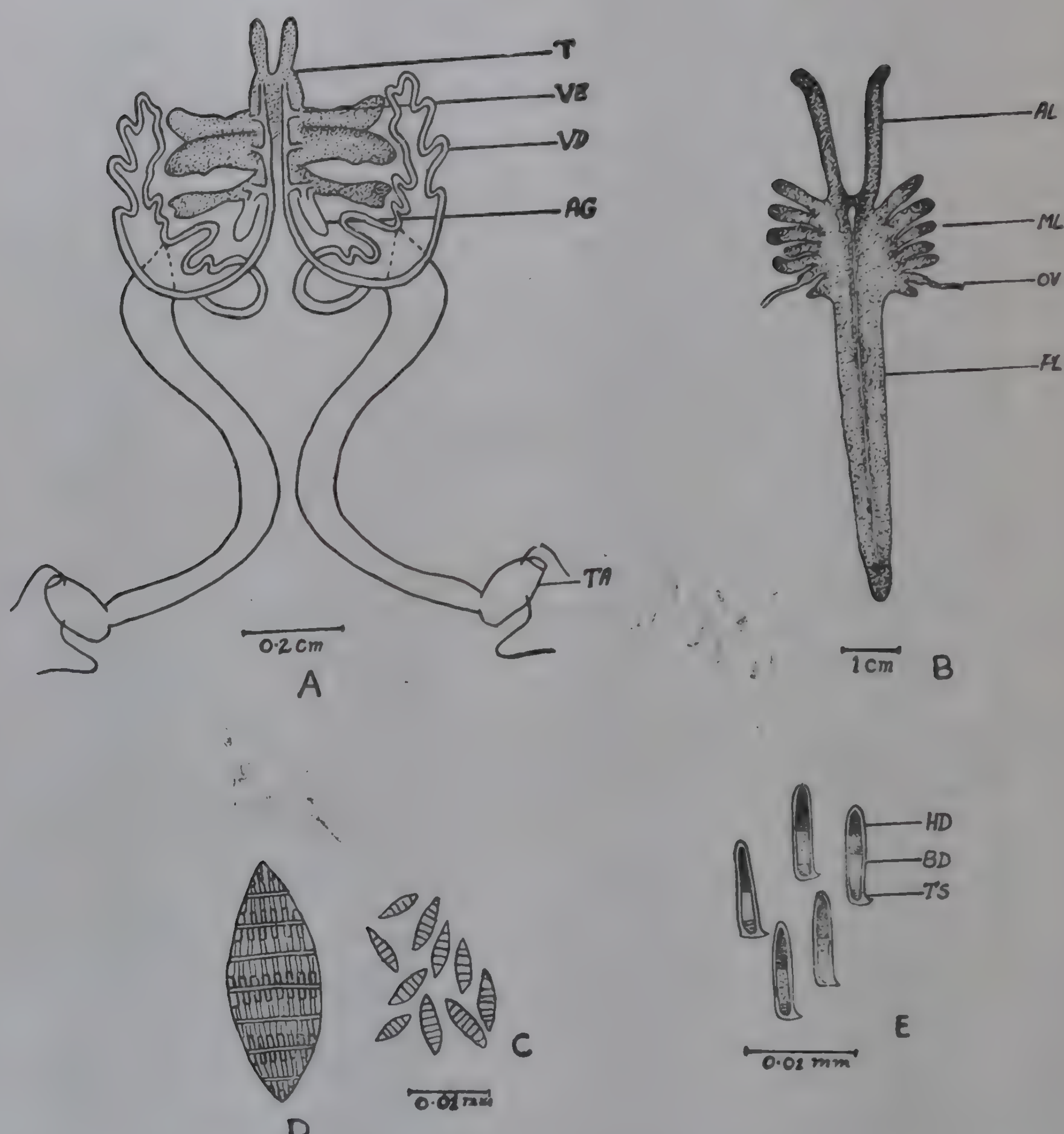

Fig. 19. *Parapenaeopsis stylifera* (H. Milne-Edwards) Reproductive systems. A. Male reproductive system, B. Female reproductive system. C. & D. Spermatophore; E. Spermatozoa; T. Testis; VE. Vas-efferens; VD. Vas-deferns; AG. Accessory gland; TA. Terminal ampoule; Al. Anterior lob; ML. Middle lobe; OV. Oviduct; PL. Posterior lobe; HD. Head piece; BD. Body and TS. Tail piece. (Shaikhmahamud and Tembe, 1958)

In Bombay waters (Mohamed, 1967a) the species appears to grow a little faster. In November 1957, the modes representing the youngest individuals were seen at 51-55 mm for males and 61-65 mm for females. These modes progressively shifted to 81-85 mm and 91-95 mm in February, showing a growth of 30 mm in three months. The monthly growth rate is therefore about 10 mm. He further observed that the smaller prawns recruited in November might have been born in May or June and they would have completed 5-6 months of life.

From the above observations it is clear that the growth rates of the species vary from place to place and the difference in growth rates may be due to the environmental conditions of the particular locality. However, since these prawns breed almost throughout the year, the interpretation of modes for determining the growth would be difficult and more improved techniques such as tagging or staining methods should be employed to confirm the above conclusions. These studies as well as that of Hall (op. cit.) thus suggest that *P. stylifera* may live for more than two years.

Differential growth of sexes:- As in other commercial penaeids of this coast, *P. stylifera* also exhibits difference in the growth rate of sexes. It has been shown that the females grow faster than males after attaining maturity. George *et al.* (in press) and Mohamed (1967a) studying the offshore fishery of Cochin and Bombay respectively come to the same conclusions.

Length-weight relationship:- The relationship between the weight and carapace length is expressed by the formula: $W = 6194\ C^{2.820}$ (Hall, op. cit.). Since the value of prawn as food is greater with the increased weight of a prawn for any particular carapace length, Hall concludes '... species of *Parapenaeopsis* are of less food value than *Penaeus indicus*, *P. merguiensis* and species of *Metapenaeus*'. But, the species constitutes a considerable percentage of the total prawn catches of India, its economic value cannot be underrated.

Movement:- As mentioned earlier, this is a non-migratory species in the sense that it does not enter into estuaries during early phase of life as in other penaeids. But in the sea it performs annual migration to

and from inshore waters. The shoreward movements commences in October. Towards the end of May at the commencement of southwest monsoon, it moves into deeper waters. The large sized prawns leave the inshore waters first and these are followed by younger ones. It has also been observed that a good number of females do not return to the coastal waters after the rains have stopped, but takes varying periods of time extending to even an year. The males do not share this habit of staying in deeper waters for longer time (Menon, op.cit.). George and Rao (1967) have shown that the females segregate together at the breeding period during October-December.

Reproduction:- P. stylifera is heterosexual. The two sexes can be distinguished by a number of external characters. The male is generally smaller in size and brighter in colour than the females; the endopodites of the first pair of pleopods are modified to from the copulatory organ called petasma and the endopod of the second pleopod also bears an accessory structure called appendix masculina. In the female, the sternal plates in between the last three pairs of thoracic legs are modified to form thelycum. The male ganital openings are paired, each aperture is situated on the coxa of last pair of pereopods. The female genital opening is also paired and are present on the bases of the coxas of third pair of walking legs.

Shaikhmahmud and Tembe (1958) have made a detailed study of the anatomy and histology of the reproductive organs of P. stylifera. The male reproductive system (Fig. 19,A) consists of a pair of testes, a pair of terminal ampoules and a petasma. The testes are situated in the thoracic region lying above the posterior half of the dorsal surface of the heptopancreas and beneath the pericardinal sinus and the heart. They are irregular in shape and each consists of three lobes, the anterior, the middle and the posterior lobes. The anterior lobe is joined in the middle with its fellow of the opposite side. Just below and behind the posterior lobe is situated an accessory gland. The vas efferens arises from each of the testes lobes and joins into the proximal part of the vas deferens which is a thin delicate tube running downwards and backwaters. In its course it receives ducts from the lobe of the testes as well as from the accessory gland. The distal part of the vasdeferens is thicker and has a wider lumen.

On the coxa of the last pair of thoracio legs, the vasdeferens gets dilated and ends in a distal terminal ampoule. It is a sac like structure with thick muscular coat and contains spermatophores and a white thicky fluid. Histologically, the testes has two different regions, one with bigger germ cells and the other with smaller glandular cells. In the mature testes, the contents of the cells of the germinal portion are in the form of spermatids and the sperm.

Sperm:- The spermatophores are oval transparent sac-like structure measuring about 0.0576 mm in breadth and 0.288 mm in length (Fig.19 C, D). In each spermatophore, the sperms are arranged in a transverse compact rows varying from 6 to 8 in number. The sperm is elongated and cylindrical in shape with a very short tail. The head piece is slightly smaller than the body and the whole spermatozoon appears to be enclosed in a thin transparent membrane. The body is followed by a tail piece. The membrane at the tail end is produced into a thin spine like process (Fig.19., E).

The female reproductive system consists of a paired ovaries, oviducts (Fig.19,B) and a single thelycum. The ovaries are bilaterally symmetrical, extending in the mature condition from the level of epigastric tooth to the tip of last abdominal segment. Each side of the ovary consists of three lobes, the anterior, the middle and the posterior lobes. The middle lobe is formed by 6 to 7 finger-like lateral lobules. The thin oviducts start from the tips of penultimate lobule of the middle lobe on either side and run downwards to external openings placed in the coxae of third pereopods. Histologically, the ovary is surrounded by a thin membrane called capsule. This is followed by a thick layer of connective tissue and an inner layer of germinal epithelium, which is distributed on certain well defined areas called 'zone of proliferation'. The remaining area is the follicular region containing immature ova. These ova are found in the centre, while the mature ones are at the perephery. At the time of spawning the follicular cells undergo degeneration.

Maturity stages of females:- Based on the external changes in colour, size, texture and microscopial examination of the ovary Shaikhmahmud and Tembe (1961) and Rao (1967) have distinguished five maturity stages (Fig.20) and they may be distinguished on the following points.

Immature stage:- The ovaries of immature prawns are thin, translucent, unpigmented and confined to the abdomen. They measure 30 to 68 mm in length and 0.65 to 1.5 mm in breadth. They contain oocytes and small spherical ova with clear cytoplasm and conspicuous nuclei. The diameter of the ova is less than 0.08 mm.

Early maturing stage:- The ovary is increasing in size and the anterior and middle lobes are developing. The dorsal surface is light yellow to yellowish, green. The length and breadth of the ovary varies from 43 to 84 mm and 1.5 to 2.0 mm respectively. Opaque yolk granules are formed in the cytoplsm and partly obscure the nuclei. The developing ova are larger than the immature stock. The majority of ova measure between 0.10 mm and 0.19 mm.

Late maturing stage:- The ovary is light green and visible through exoskeleton. The anterior and middle lobes are fully developed. It measures from 51 to 92 mm in length and 1.9 to 2.8 mm in breadth. The maturing ova are opaque due to the accumulation of more yolk and 90% of ova measure betwsen 0.14 mm and 0.27 mm.

Mature stage:- The ovary is dark green and clearly visible through exoskeleton. They occupy all the available space in cephalothorax and abdomen. They measure 49 mm to 119 mm in length and 2.9 mm to 4.0 mm in breadth. The ova are larger than in the preceding stage and the perepheral region becomes transparent. Most of ova measure from 0.21 mm to 0.35 mm in diameter.

Spent-recovering stage:- The ovaries are greatly reduced in size and are flaccid with dirty yellow or whitish in colour. It is probable that after extrusion of eggs, the gonad reverts almost immediately to the immature condition. Therefore, this stage is distinguishable from that of immature virgin females only on the size of prawn. However, Shaikhmahmud and Tembe (op. cit.) have distinguished between spent and regenerating stages also. The ova are microscopic with clear cytoplasm and conspicuous nuclei and measure below 0.096 mm.

P. stylifera attains maturity in the first year of its life. The smallest size at which the male becomes mature is 65.0 mm. The statistical

minimum size of maturation for female is 63.2 mm, but most of the females are observed to attain maturity by 70 mm size.

Mating:- There is no observation on the actual mating of these prawns. But it is believed that these prawns mate freely and mating is not confined to any particular months, but probably throughout the year (Menon, op. cit.).

Fecundity:- Mature specimens may produce an average of 39,500 eggs at 70.0 mm and 2,36,000 eggs at 120.0 mm total length. The number of eggs produced is dependant on the length of the prawn and the relationship between fecundity and total length is expressed by the formula $F = -1.5746 + 3.3437 \text{ Log } L$, where F is the fecundity and L the total length.

Spawning:- Spawning takes place in comparatively shallow coastal waters not more than 18-23 metres depth and in areas of soft mud and rich plankton. Since the eggs of the species are generally obtained in tow net collections made in early mornings, it is probable that the spawning takes place in the night time. The species breeds throughout the year, but the peak spawning season varies from place to place and from year to year. At Bombay, the peak period has been observed from December to May (Shaikhmahmud & Tembe, 1961; Mohamed, 1967a); along the Malabar coast, from November to December (Menon, op.cit.) and at Cochin (Fig.21) from November to January and April (George et.al., in press; Rao, 1967).

Multiple spawning of the species during its lifetime has been pointed out by Chopra (1943) and Menon (1953). The latter suggests the possibility of the species breeding 2 or 3 times during its lifetime of 2-3 years. Spawning more than once in an year has also been pointed out by Shaikhmahmud and Tembe (1960). Recently, utilising the data of monthly distribution of late maturing and mature females in 10 mm group, Rao (1967) has shown that the species breeds 3 times during its growth from 91-100 to 111-120 mm. Since the females attain maturity at 70.0 mm, it is quite probable that it may spawn twice before growing to 91-100mm thus the species spawns five times during its lifetime. It has also been observed that there is a gap of 2 months between the successive spawnings and during which period the immature stock of ova grows to final stage of maturity and ready for consequent spawning.

<u>Parasites</u>:- A bopyrid parasite belonging to the Genus <u>Epipenaeon</u> has been frequently found infesting the branchial chamber of prawns. A study of the gonads and external sexual organs of the parasitised prawns has revealed that these organs are imperfectly developed or remain rudimentary even in larger specimens measuring over 100.0 mm. Thus the parasites produce marked inhibitory effect on the development of sexual organs of the host.

<u>Population</u>

<u>Sex ratio</u>:- The distribution of the sex ratio of the species in the inshore fishery has been studied by Menon (1957). The following tables give the sex ratio, percentage for the two length groups representing the first and second year classes.

TABLE I

Sex ratio and percentages in total of each group

Year	All size		Over 80 mm				over 100 mm			
	Ratio		Ratio		Percentage		Ratio		Percentage	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
1952	58.6	41.4	46.5	53.5	34.6	56.2	9.3	90.7	1.3	18.0
1953	52.7	47.3	49.6	40.4	53.4	60.2	4.5	95.5	0.6	14.9
1954	50.7	49.3	44.4	55.6	58.3	74.9	1.5	93.5	0.5	34.5
1955	59.6	40.4	50.0	50.0	29.1	43.5	3.8	96.2	0.5	18.7

TABLE II

Sex ratio and percentages for all four years together

	All size		Over 80 mm		Over 100 mm	
	Male	Female	Male	Female	Male	Female
Number	2215	1753	929	997	17	327
Ratio	55.8	44.2	48.2	51.8	5.0	95.0
Percentage in total	..	..	41.9	56.9	0.8	18.7

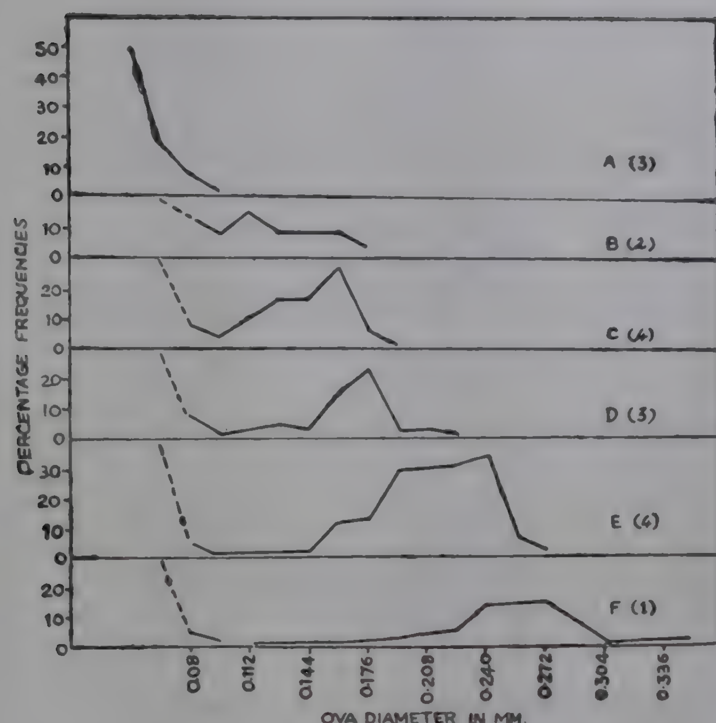

Fig 20. ***Parapenaeopsis stylifera*** (H. Milne Edwards) Size-frequency distribution of developing ova. A Immature, B and C Early maturing, D and E Late maturing, F Mature.

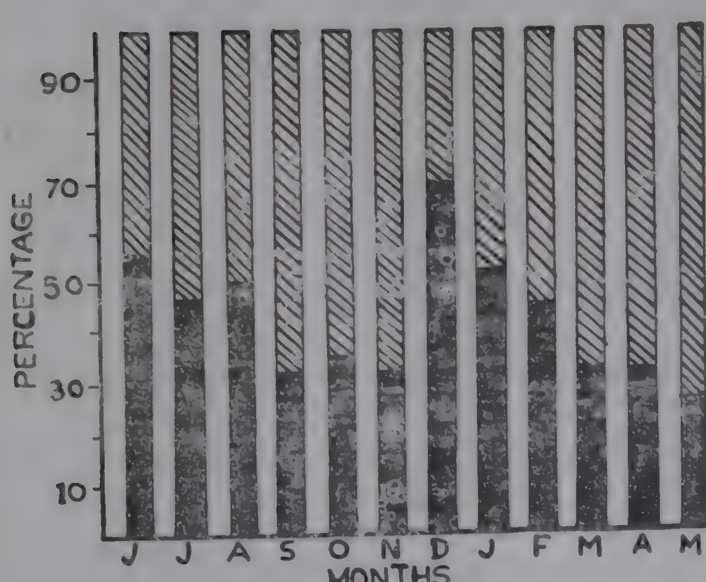

Fig. 21. ***Parapenaeopsis stylifera*** (H. Milne Edwards) Monthly percentage of prawns with ovaries in spawning and non-spawning condition.

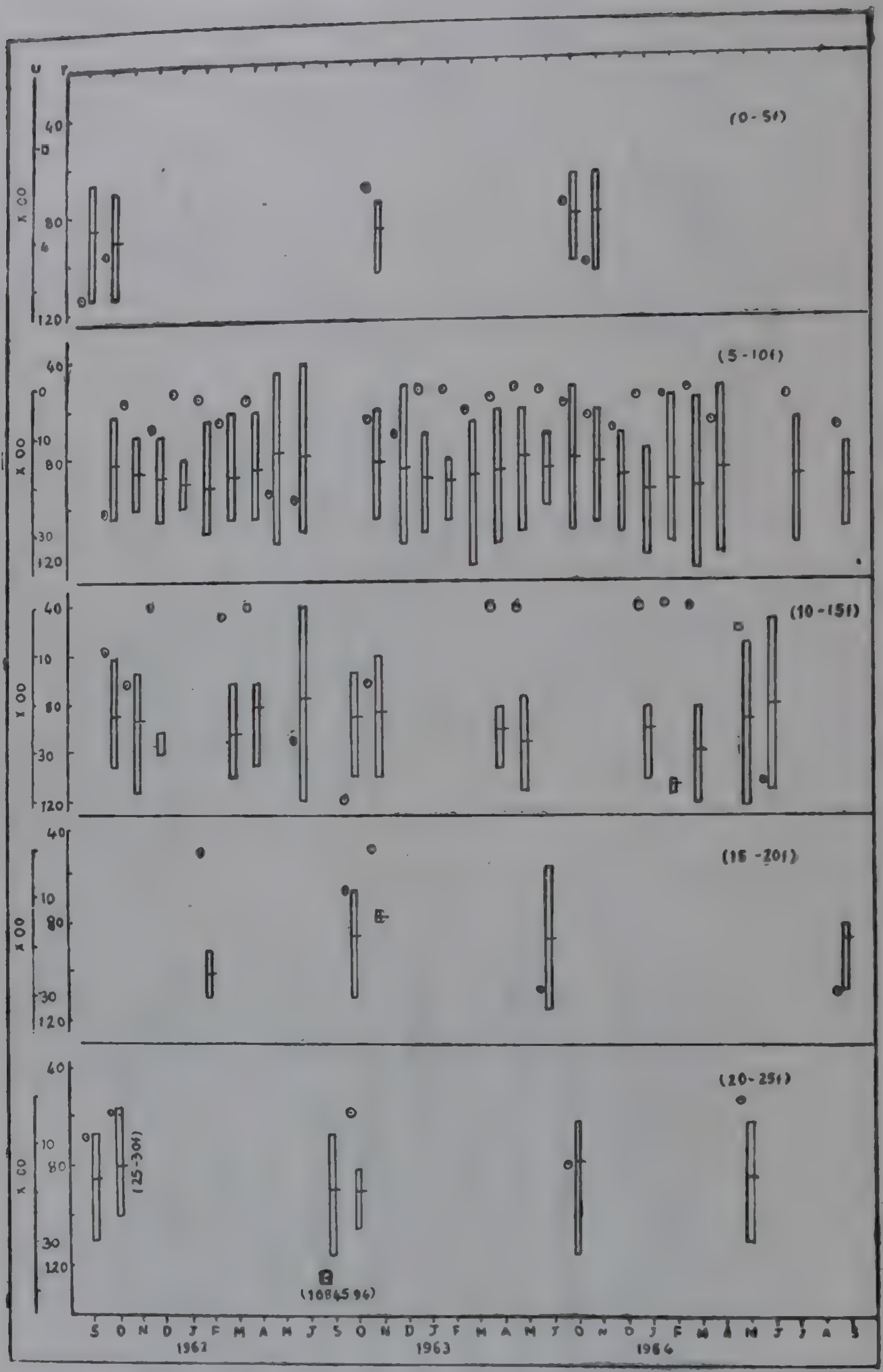

Fig. 22. Abundance and size of *Parapenaeopsis stylifera* (H. Milne Edwards) during 1961-62 to 1963-64. Vertical column represents size range (r) and the horizontal line on it the mean size in mm. Abandance (u) in number per trawling hour (After George *et. al*, 1967)

The male : female ratio for the prawns measuring up to 80.0 mm (0 year group) was 63:37; for the prawns measuring between 80.0 and 100.0 mm (first year class) 57.6:42.4 and for those measuring above 100.0 mm (Second year class) was 5.0:95.0. The estimation of the average percentage contributed by these groups to the annual fishery was 58.1:43.1, 41.2:38.2 and 0.8:18.7 respectively. From these observations it is concluded that males predominate over females noticeably both in the population and catch in the smaller groups (less than 100.0 mm size). The females become excess of males in larger size groups.

Shaikhmahmud and Tembe (1960) studying the variations in the sex-ratios of the species in Bombay waters point out that females are predominant for six months from January to June and it coincides with the peak of their breeding season.

The distribution of sex ratio of the species in the trawl fishery off Cochin is shown in table III.

TABLE III

Showing the sex ratios of P. stylifera in the trawl fishery of Cochin for the years 1962 and 1963

Months	1962			1963		
	Sample size	Males	Ratio	Sample size	Males	Ratio
January	33	9	0.27	41	17	0.41
February	43	8	0.19	29	16	0.55
March	108	47	0.43	141	65	0.46
April	49	25	0.51	251	32	0.13
May	401	174	0.43	31	13	0.42
June	818.	423	0.52	24	10	0.42
September	515	238	0.46	--	--	--
October	778	419	0.54	125	80	0.64
November	574	348	0.61	177	118	0.67
December	326	170	0.52	18	14	0.78

The statistical analysis of the sex ratio has revealed that it is significantly different from what could be accounted for by binomial theory. The male ratio is less in the exploited ground from October to December (George and Rao, 1967).

Age composition:- The population is composed of 0, first and second year class prawns. In Bombay coast, the fishery is mainly supported by 0 year group prawns (Mohamed, 1967a), while at Karwar and Mangalore 1st year class prawns dominate the catch throughout the year. In the Malabar coast, the fishery is contributed by 0 year and one year class prawns. The former group enters the fishery by March, while the latter persists from October to December-January. Along Cochin and Alleppey coasts also, the fishery is contributed by 0 year and 1st year classes. In the offshore catches of Cochin, smaller groups come to the fishery in April and from November to March larger groups predominate.

Recruitment:- At Bombay the recruitment of younger specimens takes place in the month of September-November and these prawns grow in the fishing ground contributing ~~the~~ to the fishery of the season. At Cochin and Alleppey coasts, the recruitment of small sized prawns takes place twice in an year, during April and September.

Size composition:- The recorded size range of the population as a whole is from 10.0 mm to 145.0 mm.

At Veraval, the size range of the prawns is from 60.0 mm to 130.0 mm. In October, 71-85 mm prawns dominate the catch, while in November and December slightly larger prawns measuring 90-100 mm for females and 80-90 mm for males occur in the catches. In March, 101-115 mm prawns dominate the catch.

In Bombay, smaller size groups (51-65 mm) are observed in September-November period. This group progressively attains 81-95 mm by February. At Karwar, from January to May larger females (101-120 mm) dominate and in November-December and in June slightly smaller sized females form the majority of the catches. In most of the months, males of 86-90 mm size are observed in the catches.

At Mangalore, dominant size for males and females in July is 81-90 mm and 91-105 mm and at Cannanore during the peak fishery season in December-February, prawns measuring between 76-80 mm and 91-95 mm dominate.

At Cochin coast, the females measuring 96-100 mm and males 81-95 mm dominate from January to March. In April and May both the smaller as well as larger groups are present. Soon after the rainy season, when the fishery commences in September, 91-100 mm size prawns are caught and in the succeeding months up to December 71-95 mm prawns are found in abundance. The depth-wise size distribution of the species in the fishing ground off Cochin was studied by George _et al_. (1967). In 9-18 meter area the size of the prawn increases gradually to reach the mean size of 90-95 mm by January-February and then it declines. In 18-27 meter zone mean size of 111.0 mm was recorded in February. In the deeper zones of beyond 27 m. the size was comparatively low varying from 77-90 mm.

Abundance:- Estimation of the population size is not available. In the inshore water, the species is abundant up to 22 m., especially from the depth ranges of 12-15 m and 15-20 m.

At Veraval, the species supports a good fishery during October-December period. In Bombay, the species is caught throughout the year, but forms the significant portion of the catch when the fishery commences in September. The same trend is maintained in the next month also. In November its proportion slightly declines. During January-February the species again contributes to the fishery and in April-May also their catch is comparatively high.

At Karwar, the species ranks second in the prawn catches landed by trawlers. It is abundantly caught in the inshore fishery during April, July and August. At Mangalore, the peak season is from January to April, while at Cannanore, it is from December to February. In the Malabar coast, the species is most abundant in the catches during summer months, from February to May. In the southwest coast of India, the species stands next to _Metapenaeus dobsoni_ in abundance and the peak of the fishery season is September-October, January-February and in some years in April.

Their depth-wise abundance was studied by George _et al_. (1967). In 1961-62 season, the species was comparatively low in shallow waters (0 to 9 m) during the beginning of the season. But their abundance ranged from 124.14 to 2608.56 (catch in numbers per trawl hour) in the depth zone 9 to 18 m with maximum in October and minimum in January. In the area of

18-27 m deep, their abundance varied from 10.99 in December to 2844.53 in June and high abundance was recorded in September-October in the deeper zone (27-45 m). In 1962-63 season, a maximum abundance of 1035.88 was recorded in December and the minimum of 75.51 in May in zone 9-18 m. In 18-27 m. area high values of abundance were obtained in October and November. In the deeper areas maximum of abundance was in September and June. In 1963-64 season, high abundance was noticed from December to May in 9-18 m area and in June in the next deeper zone. As in the previous years, the catch was good in the 27-45 m. depth zone in October. From these studies it is concluded that the species is scarce in the lower depths during the beginning of the season after the southwest monsoon, but are found in abundance in the deeper waters beyond 27 m depth. From November to February-May the species is generally encountered at a depth varying between 9 and 27 m. (Fig22).

Fishing methods:- In Bombay area, the indigenous gear, 'Dol' or bag net is the gear used for catching prawns. This net is made of either cotton yarn or hemp. The small nets vary in size from 35' to 50' in length with a mesh size from ½" to 2" and are known as 'Bokshi', while the larger 'Dol' nets vary from 130' to 150' in length. The details of the dol nets and their operation have been described by Setna (1949). In the North Kanara coast, the prawns are caught by shore seines (Yendi bale) the details of which are given by Pradhan (1956). In the southwest coast of India, various types of boat seines, shore seines, drag nets and cast nets are employed. On the east coast, the bottom drag net and the bag nets are used. The mechanised fishing for prawns has been introduced recently and various sizes of shrimp trawls are used. The most common shrimp trawl is 2 to 4 seam trawl varying from 13 to 18 m in head rope length and with mesh sizes of 76 mm, 50 mm, 38 mm and 25 mm for wing, body, throat, and cod end respectively.

The indigenous gears are mainly operated by dug-out canoes and plank-built boats without out-rigger. The mechanised fishing vessels are generally the medium sized 7-11 m. pablo boats having 10-30 b.h.p. engines.

Fishing areas:- There is a regular commercial exploitation of the species in West Pakistan, west coast of India and in lesser extent on the east coast of India. It is found in large shoals in the shallow waters

and forms an important species both in the inshore and offshore fishery. The general fishing ground has a muddy bottom and the species seems to prefer soft mud. As mentioned earlier, it cannot tolerate low salinity. The hydrological features of the sea water at Alleppey and Narakkal during the peak of the fishing season has shown that the dissolved oxygen varies from 3.25 to 4.82 c.c./litre, salinity from 28.09 ‰ to 34.06 ‰, surface temperature 27.8°C to 29.5°C and pH 8.30 to 8.38 (George, 1961).

Fishing season:- Although the species occurs all the year round in the west coast of India, it abounds the inshore waters from November-December to May-June and offshore waters in September-October. At Veraval, the species supports a good fishery in October-December. In Bombay coast, the fishery starts in September and the peak months are September, October, January to April-May. At Karwar, April, July and August are the main seasons for the fishery. At Mangalore, the peak season is from January to April, while on the Malabar coast, the fishery commences in October and reaches the peak in February-May. Along Cochin coast, the fishery starts from September-October and the maximum catch was observed during December-January and April-May.

Catch:- The species contributes approximately 18.0% of the annual prawn catch of the Country, which varied from 62,768 m. tons to 94,895 m. tons during the period 1958-65. Wide fluctuations in the percentage composition of the species in the total estimated landings of Bombay is observed. During 1952-53 and 1954-55 season, it formed 26.4% of the total prawn catch landed at Sassoon Dock, while it is only 6.31% for the years 1959 to 1963. At Karwar, the species forms about 8 to 10% of the annual prawn catch, while in Mangalore it is as high as 31.5% of the total estimated landings. At Cochin waters, the percentage of *P. stylifera* varies in different months from 2.8 to 40.2, and the annual catch per hour of trawling for the seasons 1957-'58 to 1962-'63 were 52.1, 60.5, 41.6, 39.8, 64.4 and 43.2 kg respectively (George *et al.*, in press).

2. PARAPENAEOPSIS SCULPTILIS (HELLER, 1862)

This is another species of economic importance, although it does not contribute to the extent of that of P. stylifera. Heller in 1862 first described the species and the diagnostic characters are as follows:

Rostrum-Teeth 6-8+epigastric, latter always feeble, often represented by a barely perceptible depression in male. Apparently sexually dimorphic in male measuring 70.0 mm and above, unarmed portion absent, rostrum curving downwards, reaching to 2nd segment of antennular peduncle; in female rostrum is long, strongly sigmoidal, unarmed distal ½ strongly upcurved and reaching beyond tip of antennular peduncle. Epigastric tooth 1/5 carapace, 1st tooth at or slightly behind anterior margion of carapace, 1st tooth at or slightly behind anterior margin of carapace. Postrostral carina low, of uniform height, ending 1/20 length of carpace from posterior end; feebly sulcate, sometimes merely flat-topped throughout its length and narrowing slightly about the middle. Adrostral carina ending mid-way between 1st and 2nd teeth. Carapace - orbital angle small. Longitudinal suture reaching 3/4 length of carapace from postorbital margin and reaching level of transverse suture. Orbito-antennal sulcus absent. Antennal spine large, the carina reaching ½ distance between spine and hepatic spine. Cervical sulcus straight, feeble, wide, its upper end indistinct. Hepatic sulcus pronounced 1/3-½ length of carapace inclined downwards at angle of 15° to horizontal, sinous, posterior end indistinct and curving upwards, ending at ½ carapace at level of hepatic spine; hepatic carina distinct only for lower ½ sulcus, starting below hepatic spine and running towards sharp pterygostomial angle. Febble indication of branchiocardiac sulcus usually present. Antennules - Flagella subequal; prosartema reaching tip of junction of peduncle of eye with cornea; stylocerite attaining ½ basal segment. Thoracic appendages - Third maxilliped reaching from 3/4 to slightly exceeding carpocerite. 1st pereopod reaching from pterygostomial angle to base of carpocerite; 2nd reaching from base to ½ carpocerite; 3rd reaching from tip to exceeding carpocerite by dactyl; 4th reaching base of, 5th reaching tip of carpocerite. Mastigobranchiae on 1st and 2nd pereopods, ischial spines absent.

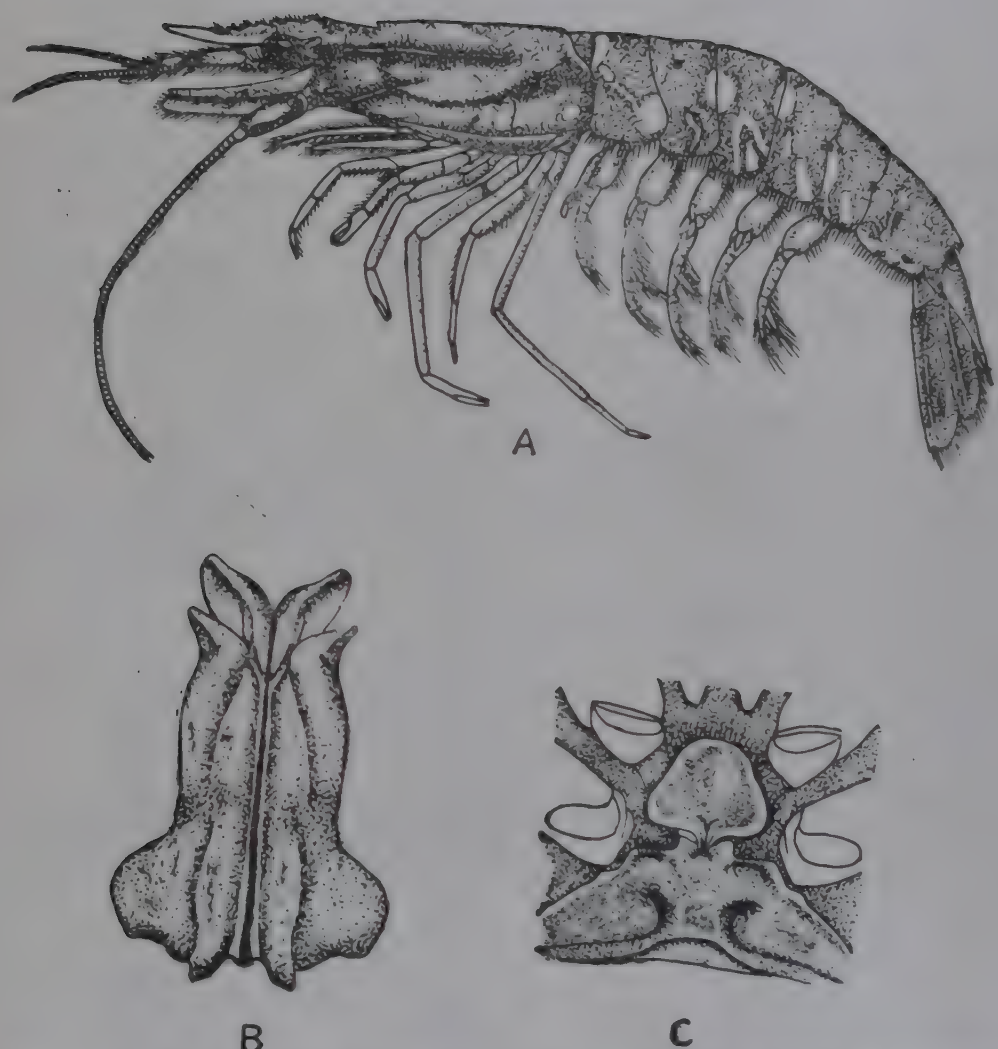

Fig. 23 *Parapenaeopsis sculptilis* (Heller), A. An adult male, B. Petasma; C. Thelycum,

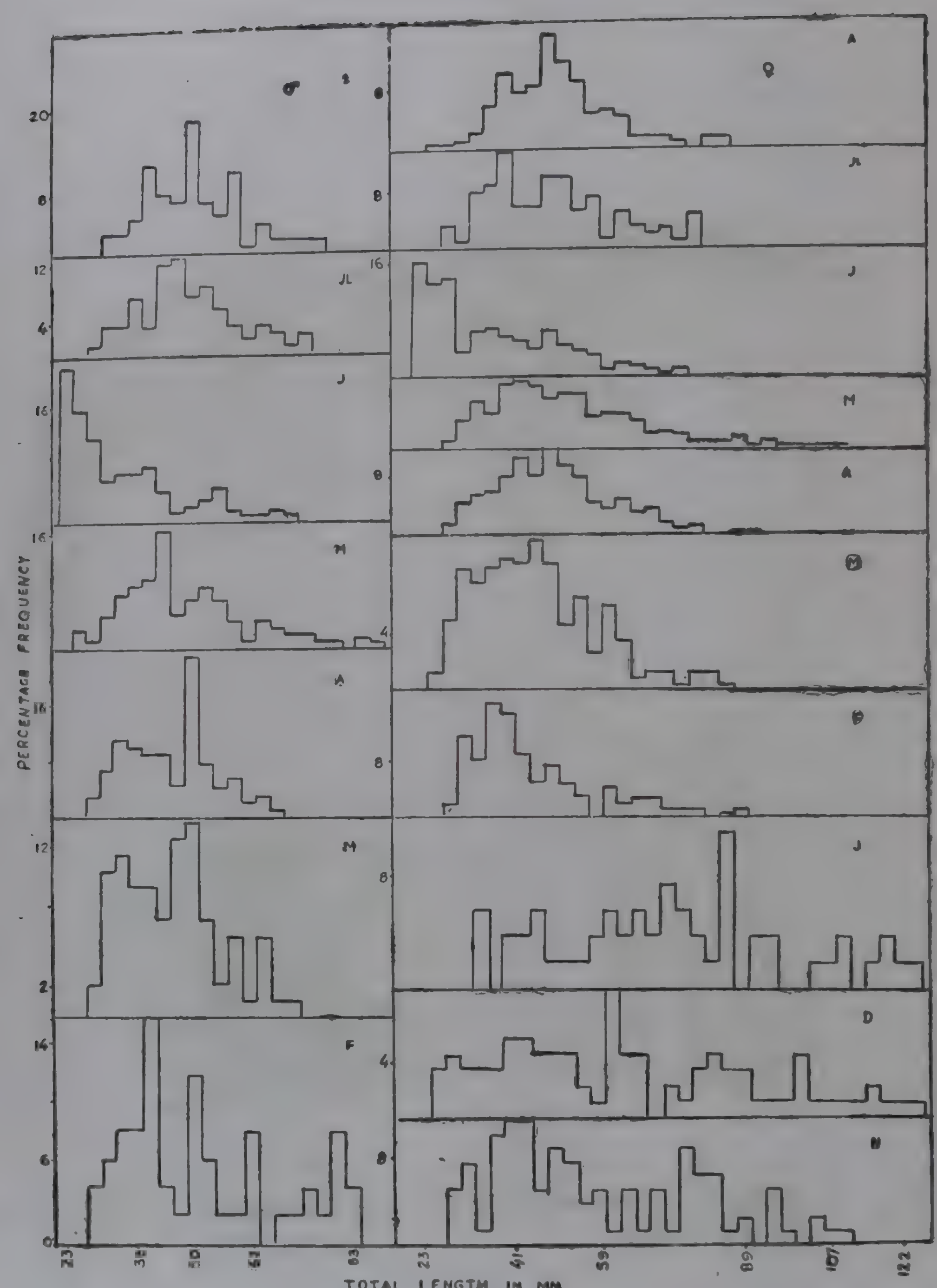

Fig. 24. *Parapenaeopsis sculptilis* (Heller) Percentage length frequency distribution from month to month in males and females (After Rajyalakshmi, 1966)

Abdomen - Dorsally carinated from middle of 4th somite, carinae of 4th and 5th ending in angular, sometimes very minutely spinnous projections, that of 6th ending in a large spine. The third and anterior 4th somite with feeble dorsal sulcus or flat topped strip indicating its position, often present on 1st and 2nd somites also. 4th somite with 1, 5th with 1 and 6th with 3 pairs of faint lateral cicatrices. Telson unarmed (Fig.23,A). Petasma (Fig.23B) - Reaching basis of 4th pereopod, with pair apical spout like projections directed anterolaterally and opening ventrally, distance between their apices almost equal that of distolateral projections, which is 2/5 total length of petasma. Petasma constricted at 0.7 its length, a pair of very large prominent lateral proximal projections, slightly curved distally, ending posteriorly in knob-like processes. Appendix masculina - Distal piece with expanded, flattened distolateral region inclined at 45° to longitudinal axis and ½ length basal piece. Thelycum (Fig.23C) - Anterior plate slightly concave, length 0.7-0.8 width; with 2 low tubercles on posterior edge separated by shallow median depression and articulating with corresponding pair of tubercles on rectangular posterior sternal plate, latter with tubercle bearing tuft of setae.

Colour - Four wide whitish transverse bands evenly spaced along carapace and abdomen, edged with narrow pink bands, region between white and pink bands light to dark brown; appendages pink to red.

Although, the species is well established, Hall (1962) claims that this species in fact is *Penaeus affinis* Milne-Edwards, 1837. But Burkenroad (1963a and 1963b), Racek and Dall (1965) and Kirkegaard and Walker (1967) do not upheld this view.

Alcock (1906) created a variety, *P. sculptilis* var. *cultirostris* for 18 males which possess straight rostra which are nearly horizontal and do not reach further than the middle of the 2nd joint of antennular peduncle, but have a peculiar dagger shape. Kubo (1949) raised this variety to specific rank. Dall (1957) synonymised both Alcock's variety and Kubo's species, *P. cultirostris* with *P. sculptilis*, pointing to the fact that cultrate condition of the rostrum is invariably found in males of the latter species after copulation. The position of epigastric tooth, sulcation of postrostral carina and first and second abdominal somites are variable and therefore not valid for creating a distinct species.

However, Hall (*op.cit.*) disagrees with Dall's view and suggests that although there are similarities between the rostra of adult male of *P. sculptilis* and the variety *cultirostris*, the precise form of *cultirostris* rostrum is shown in the Malaysian form by the adult male of *P. hardwickii* and it is with this species that the variety *cultirostris* is to be synonimised. Recently, Racek and Dall (*op. cit.*) pointed out that the cultrate condition of the rostra in the males of *P. sculptilis* and *P. hardwickii* display close affinities and in view of these similarities they suggest that it is possible that Alcock's material of *P. s. cultirostris* may consist of both species, eventhough, they could readily be distinguished from each other by their secondary sexual characters. Thus, the status of this variety is still unsettled.

P. sculptilis is known by the standard name - 'Rain bow prawn' and locally in Australia it is also called 'Coral prawn'. In New Guinea, it is known by a variety of vernacular names such as 'Brown coral prawn', 'Tiger prawn', 'Long beaked prawn' and 'Short beaked prawn'.

Distribution

This is a widely distributed tropical species, found from west and east coasts of India to Hongkong through Malaysian waters and Indonesia to tropical Australia and New Guinea. The northern and southern limits of this species lie just inside the tropics of Cancer and Capricorn and within these limits its distribution could be considered as Indo-West Pacific. Its abundance in commercial quantities has been reported from Penang, Singapore (Malaysia), Java (Indonesia) and from Queensland, east coast (Australia). It is also forms a good portion of the prawn fishery in Keppel Bay (Dall, 1957) and at Papua.

In India, commercial exploitation of the species is done at Kutch, Bombay in the west coast and in the Hooghly estuarine system in the east coast. It is also reported from the Godavari river system almost throughout the year.

Life history

No information is available on the eggs and nauplial stages. Kirkegaard and Walker (1967) have recorded a series of small larvae of the

species with 8+8 telson spines in the plankton samples taken from the Norman river (Australia). Protozoeae were found in June when the salinity of the river was between 30‰ and 32‰, mysis stages in water below 22‰ and juveniles up-river in water below 5‰. The juveniles have also been recorded from the Hooghly estuarine system in June, November, March and May (Rajyalakshmi, 1966). According to Hall (1962) the juveniles of his P. affinis (P. sculptilis) occupy the tidal flats for 2 or 3 months and then they migrate to deeper waters.

Food and feeding:- No observation on the stomach contents of the species has been made from the Indian region. However, Hall (op. cit.) examined the stomach content of 21 specimens and grouped it under those prawns with a general carnivorous diet mainly feeding on polychaets, crustaceans and molluscs. The specimens studied by him measured from 1.3 to 3.8 cm carapace and were from the 'Ambai' fishery of Penang. The stomachs were on the average about half full and he gave the following table for the composition of stomach contents of the species studied.

Item	Predominant	Residual	Total
Polychaeta	4	5	9
Small crustacea (Organisms ingested as whole)	-	7	7
Large crustacea (Those organisms of which only parts are ingested)	3	7	10
Mollusca	11	6	17
Pisces	-	2	2
Vegetable	-	2	2

He further observes "The only items of small crustacean debris which were identifiable were of Herpacticoid copepod. The large crustacean material, apart from two records of gammarid amphipods, appeared to consist of portions of decapods. Both the records of fish debris included vertebrae. All the molluscan material appeared to be of a single species of protobranchiata and although this item was by far the most important found in the stomachs of P. affinis, there was one record of a 'split bolus' in which probobranch material formed the posterior one-third of the

volume while decapod crustacean material formed the more recently ingested anterior two-thirds.

Detritus formed but a very small portion of the contents of the stomach".

All the prawns which had a high proportion of mollusca were obtained from the 'Ambai' fishery on Batu Maung flat, Penang and this flat is mainly of mud and bivalves inhabit the surface of the mud. It appears that the molluscan material was taken by these prawns in proportion with its availability and they do not select the food material.

Growth:- By employing the probability plot method, Rajyalakshmi (1966) has shown that the juveniles of the species grow approximately 12-15 mm per month in the very early months after hatching. This rate declines later and by the end of first year males attain length of 45.0 mm to 59.0 mm and females 50.0 mm to 65.0 mm. The growth rate maintains a constant proportion during later years and the increments in length attained by males during second year is 30 mm and by females 25.5 mm to 29.0 mm. The females appear to live one more year than the males and in the third year of the life the increment in growth is approximately 25.0 to 29.0 mm. Faster rate of growth is observed in females indicating a sexual difference in the rate of growth (Figs. 24 & 25).

Hall (1962) based on the length frequency distribution of males and females obtained from the 'Ambai' fishery, fitted growth curves to the data for the period October to February. The curves indicate an increase in carapace length from below 0.5 cm to 2.0 cm for males and 2.25 cm for females in that four month period.

Length-weight relationship:- This aspect has been studied by Hall (1962) and Bhimachar (1963). The relationship is expressed by the following formula:

$W = 0.4954\ C^{2.944}$ (Hall, op. cit.)

$W = -5.1272+2.9580 \text{ Log } L$ (Bhimachar, op. cit.).

where 'W' is the weight, 'L' is the total length and 'C' the carapace length.

Movement:- The species does not appear to have extensive migration and according to Kirkegaard and Walker (op. cit.) it does not move far from the river mouths. The larvae and juveniles migrate upstream; 0-1 year group contributing to the fishery of less saline areas. The larger specimens (adults) move out of the less saline areas and are generally caught in tidal marine zones or in the inshore marine regions. On the Batu Maung flats of Penang, Hall (1962) found that the juveniles move into the flats in November-December and after 2 or 3 months disperse into deeper waters. He explains this movement is mainly due to the shallow nature of flats and certain areas getting dried up during low tides and apparently unsuitable for juveniles.

Reproduction:- P. sculptilis is heterosexual and sexually dimorphic. The males are distinguished by smaller sizes, lack of anterior edentate portion of rostrum extending beyond last rostral tooth to beyond tip of antennular peduncle in specimens measuring above 70 mm and the secondary sexual characters like the petasma and appendix masculina. In the females, the presence of thelycum and the anterior edentate portion of rostrum extending to the tip of antennular peduncle are characteristic.

No detailed study on the maturation process of the gonads has been made. Bhimachar (op. cit.) gives the size of males at sexual maturity as 75.0 mm and the females also attain maturity at this size according to Rajyalakshmi.

There is no information on mating, fecundity or fertelisation. However, it is likely that the mating is promiscous and fertilisation takes place externally as in other penaeid prawns.

Spawning takes place in the inshore waters extending from December to April-May with peaks in December-January (Rajyalakshmi, 1966). In Bombay waters, although the females with ripe ovary occur throughout the year, intensive breeding activity as indicated by the occurrence of mature females is observed during December-February.

Population

Sex-ratio:- Studies on the sex ratio of the species in the fishery of Hooghly estuarine system have indicated that the ratio changes generally with the size and the season. In younger individuals (23mm to 26 mm size range) the sex ratio is equal, but in the slightly higher sizes of 29 mm to 69 mm the male to female ratio is 1:3.24. In prawns measuring above 89.0 mm only females are found. Sex-wise length frequency distribution has indicated that generally females grow to bigger sizes and greater ages. The equality seen in the sex ratio of younger individuals and the disparity in the large sized prawns might indicate either a higher rate of mortality in males or segregated movement of one sex after certain sizes.

In the Bombay fishery, the females are found to dominate over the males.

Size composition:- The maximum size recorded so far is 152.0 mm total length. However, Filewood (1964) gives a variable measurement of 6-7 inches. Small sized males of 23.5 mm modal size occur in June, while females are encountered in November (29.7 mm), December (27.8 mm), March (29.4 mm), May (30.5 mm) and in June (24.2 mm) in the estuarine catches of Hooghly river system. Higher age classes have a bimodal length frequency distribution for each year group and this might be due to the prolonged spawning season.

At Bombay, during 1959-60 season, more than 15% of the prawns were within 55 to 105 mm size range in September-November period. A gradual increase of size from 75 mm in September to 135 mm in March was also observed. Juveniles measuring 25.0 mm appeared in January.

Munro (1966) gives a range of sizes interms of whole count per pound of a particular specimen or sample and observes that counts per pound ranged from 20-173 and throughout the season individuals were distributed throughout this full size range.

Age composition:- Smaller individuals belonging to 0-1 year age groups contribute to the fishery of less saline areas and the larger specimens (2nd and 3rd years) support the inshore fishery. Thus the fishery depends on populations with a dominance of certain year groups.

In the Queensland fishery, the year groups are well mixed in the 1 to 3 fathom depth zone, while the 'Ambai' fishery of Penang shows a fairly uniform mixing of age groups but with an influx of juveniles in October-December period.

Abundance:- In the Gulf of Kutch area, the species occurs regularly and at Modhwa it forms about 18.8% of the total prawn catch during September-January period.

In Bombay coast, the species occurs throughout the year, but available in commercial quantities from October-November to May with peaks in December-February. At Sasson Docks and Arnala, the fishery is quite considerable contributing 42.23% and 34.10% respectively of the total annual landings of prawns. It was found to be the second most important fishery at Arnala. Though, the fishery was observed to be relatively less important at Versova, the landings of the centre were comparable with that at Sassoon Docks in the month January (Kunju, 1967).

In the Hooghly estuarine system, the species is dominant in the winter and monsoon months.

Weather appears to cause changes in abundance, although, the total population size may not be altered. In Penang, this species is relatively abundant on four occasions, one during each steady southwest monsoonn and at the beginning and end of the northeast monsoon (Hall, 1962).

Munro (1966) states that P. sculptilis is mainly confined to the fringes of the coast out to the four fathom contour in the Gulf of Carpentaria, but may be found as deep as 7 fathoms. The greatest concentrations were found around river mouths in depths of less than 3 fathoms. In Bombay, large numbers are caught at a depth range of 2 to 8 fathoms.

Seasonal variations are also observed by Munro who states "Occurrence is seasonal but it is likely that the species occurs in rivers throughout the year .... this epcies moves into coastal waters during monsoon season. Although small numbers were observed as early as August and as late as May, the main period of abundance coincided with the wet season and immediately prior to it, namely November to March".

The species seems to inhabit the bottom of different types such as sand, mud, mud flats, mud with fine shell particles, fine sloppy alluvial silt and clean sand mixed with coarse shell and gravel (Hall, 1962; Ramamurthy, 1963 and Munro, 1966). In the Gulf of Kutch area, Ramamurthy (op. cit.) found that an increase in percentage in the catches taken over sandy bottoms instead of muddy bottom .

Fishing methods:- In India three types of gears, viz., stake nets (bag nets), boat seines and trawl nets are used for catching these prawns. The former two types of gears are generally employed in shallow inshore waters of Bombay and in the estuarine regions of Hooghly and Godavary. The details of the structure and operation of these nets are described by Setna (1949) and Rajyalakshmi (1966). The trawl nets are used in the deeper waters.

The shrimp fishery of Singapore employs a push net known locally as the "Sondong". This is a net hung on two poles 10 to 15' long which cross about 2 feet from the thicker ends and have shoes fitted to the other ends. The net is made up as a scoop and pushed along in shallow water by the operator. Periodically the net is lifted and the catch taken back to the operator. The hauling seine used in Singapore is known as the "Pukat Tarek" which has a roughly cone shaped bag about 36' deep with wings 500' long tapering to a depth of 9'. Rattan leads 2500' long are used for hauling. Cotton twine in three sizes is used to make up the net and the mesh size tapers from 2½" in the extremities of the wings to 1¼" at the mouth of the bag. It is handed as a beach seine by up to 16 men from a row boat (Kirkegaard and Walker, 1967).

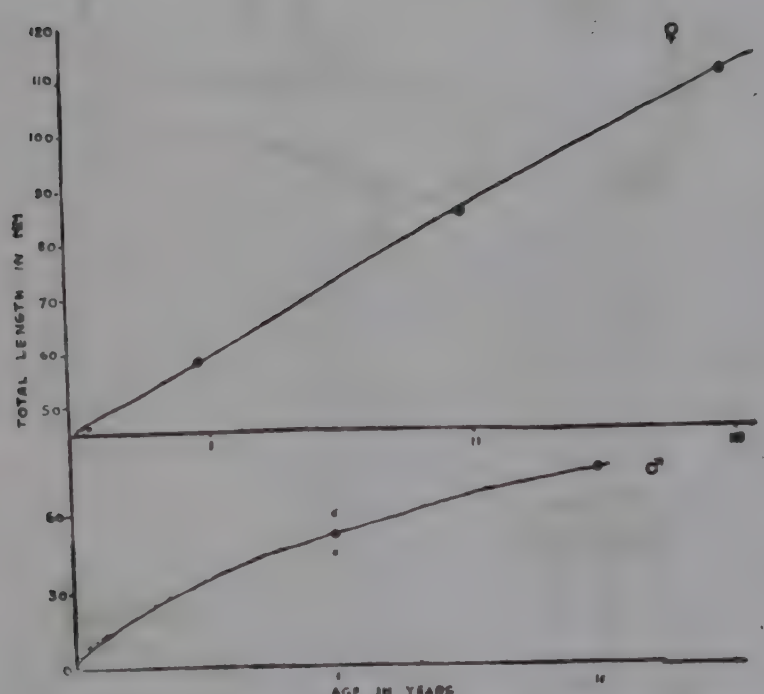

Fig. 25. *Parapenaeopsis sculptilis* (Heller) Approximate growth rate curve in males and females (After Rajyalakshmi, 1966)

Fig. 26. *Parapenaeopsis hardwickii* (Miers) A. An adult male, B Petasma; C. Thelycum.

In Penang, the 'Ambai', a device made up with the rows of stakes set in a linked set of 'V' shapes with bag nets at apices is used. This can be operated to a particular tide or both the phase of tide.

Beam or otter board trawls are used in the Queensland fishery. Mesh size is from 1 to 1¾ inches in the cod end, width varies from 6 to 10 feet wide (beam trawl) to 8 fathoms (otter trawl). The beam trawl is also used in estuaries and otter trawls both in estuaries and outside river mouths.

The beam trawl fishery in the estuaries of Australia use small boats of 20 feet long with 5 to 20 b.h.p. inboard motors. The details of these vessels and their design are given by Wright (1966) and Kirkegaard and Walker (op. cit.).

Fishing season:- In India, the inshore fishing seasons extend from October to May and in the river systems during monsoons. In Queensland, this is fished from the coastal waters in November-December. At Penang, the species is available in large quantities from October to December-January.

Catches:- The species forms about 0.8% of the annual prawn catches of India (Mohamed, 1967b). In the Gulf of Kutch where 60% of annual average marine fish production of 1250 tonnes consists of prawns, of which this species forms about 6% of the annual catch. The average annual catches at Versova, Sassoon Dock and Arnala were 71.171, 127.052 and 102.587 m. tonnes respectively, forming 2.24, 5.90 and 10.41 percentages.

3. PARAPENAEOPSIS HARDWICKII (MIERS, 1878)

This species ranks third among the commercially exploited species of the genus Parapenaeopsis in the Indian region. It is popularly known as 'hard spear prawn' in Hong Kong (Cheung, 1960). P. hardwickii is closely related to P. sculptilis, but can be distinguished from it by the characters given below.

Rostrum sigmoidal, distal half or more styliform and edentate, strongly upcurved; in female at least $\frac{1}{4}$ of rostrum extending beyond tip of antennular peduncle; rostrum in mature male often cultrate and not exceeding beyond 2nd antennular segment; dorsally armed with 7-8 teeth+ epigastric. Adrostral carina ending about half way between epigastric and penultimate tooth, sulcus shallow. Postorstral carina distinct, almost reaching posterior margin of carapace, with a broadly open sulcus.

Orbital spine not much more than a sharp angle, postocular sulcus moderately deep, at angle 40° to rostrum. Longitudinal suture reaching about 8/10 carapace, distinct in the entire length. Cervical sulcus shallow and short, not quite reaching longitudinal suture. Antennal spine prominent antennal carina reaching to 2/3 distance between hepatic and antennal spines. Hepatic sulcus pronounced, some what more than 1/3 length of carapace, slightly sinuous; hepatic carina distinct only for lower half sulcus, commencing from base of hepatic spine, and reaching to the vicinity of the sharp pterygostomian angle. Branchiocardiac sulcus barely perceptible(Fig.26,A).

Antennular flagella not sexually dimorphic, slightly longer than their peduncle, which is 0.6 length of carapace.

Third maxilliped surpassing carpocerite by dactyl; 1st pereopod not quite reaching to base of carpocerite, 2nd surpassing it by dactyl; 3rd as long as outer maxillipeds, 4th reaching to base of carpocerite, 5th attaining anterior margion of cornea. Mastigobranchiae and slender basial spines on 1st and 2nd pereopods.

Abdominal carination beginning from anterior 8/10 of 3rd somite, carina on 6th ending in a sharp spine; dorsal sulcus absent. Two lateral

cicatrices on 4th and 5th somites, 3 on 6th somite. Telson armed with 3-5, usually 4 pairs of mobile spines, of which the apical set is the largest.

In the petasma (Fig. 26, B) the distomedian projections not extending beyond tips of distolateral projections, about as long as wide, their anterolateral margins distinctly crenulated; distolateral projections pointing laterally; proximal lateral enlargements of petasma very large and rounded.

In the thelycum (Fig. 26, C) the anterior plate is slightly concave, wider than long, anteriorly and posterolaterally rounded; sternal plate between 5th pereopods flat, with a pair of anterolateral tooth-like process directed anteriorly, and a concave anteromedian margin bearing a transverse row of long setae.

Distribution

The general distribution of the species is from the coasts of India through Malaysia to Southern China. Although, the species occurs on both the coasts of India, it supports a good fishery only in Bombay and in lesser magnitude in Andhra coast. Its commercial exploitation has also been reported from Penang in Singapore (Hall, 1962).

Life-history

Eggs and larvae:- No information is available on the eggs and larval stages of the species. But Hall (op. cit.) believes that the species breeds in deeper waters and the young ones migrate to shallow inshore waters, where a portion of their life is spent.

Food and feeding:- The only observation on the food of the species was that of Hall (op. cit.) who studied 28 specimens ranging in carapace length from 1.0 cm to 1.7 cm, from the Penang 'Ambai' fishery. Nine of the stomachs examined by him were less than half full, but the remainder were full. The important food items ingested by the species are given below.

Item	Predominant	Residual	Total
Polychaeta	1	6	7
Small crustacea	1	13	14
Large crustacea	9	11	20
Molluscs	21	6	27
Pisces	-	7	7
Vegetable	-	1	1

He further commented that among thesmall crustacean debris were recognised to be composed of harpacticoid and calanoid copepods, ostracods and one cumaoea. The one occasion on which the small crustacea formed the predominating feature of the stomach content was when harpacticoid copepods and ostracods were present together. The only large crustacea which were identified from the stomach of this species were Mysidacea. By far, the mass of molluscan material consisted of debris of protobranch lamellibranchs, but little gastropod debris was also observed. Although, the detritus was found in almost every stomach the amount was very small.

As P. sculptilis, this species has also been placed in a group of species with a general carnivorous diet.

Growth:- Hall (op. cit.) studied the size-frequency distribution of males and females of P. hardwickii from the 'Ambai' fishery, and fitted the growth curve to the data. The curves indicate an increase in carapace length from below 0.5 cm to about 1.25 cm in males and about 1.275 cm in females during four months from October to January. Since the juveniles of P. hardwickii of 0.4 cm to 0.5 cm carapace length are observed in October, he estimates that this size has been attained in about 4 to 5 weeks from spawning which takes place in September. Length-weight relationship has been given by: $W = 0.5808\ C^{2.824}$.

Reproduction:- P. hardwickii is heterosexual, distinguished externally by the secondary sexual characters like petasma and appendix masculina in male and the thelycum in female. No observation has so far been done on the maturation process, spawning behaviour and on the

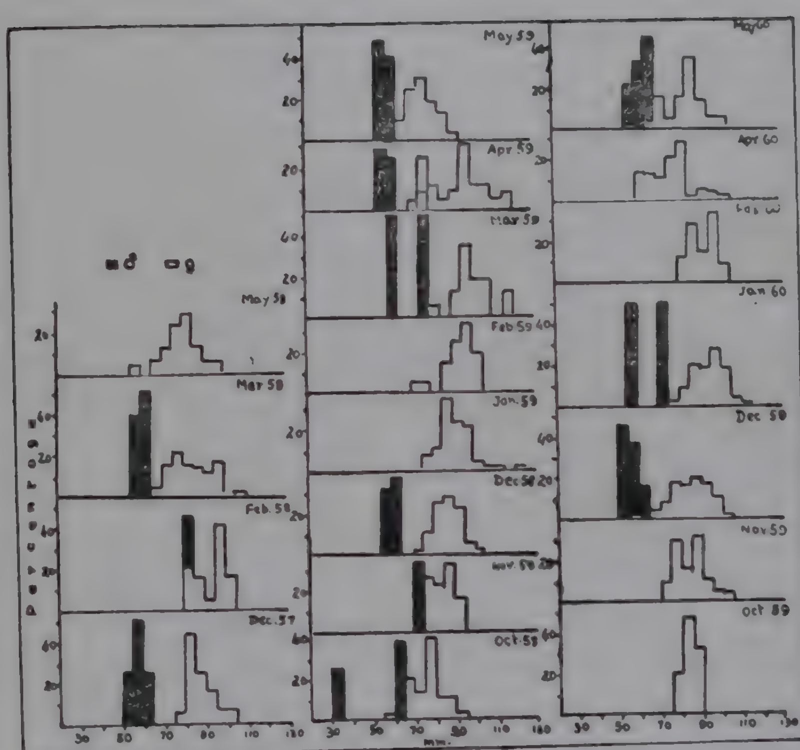

Fig. 27. *Parapenaeopsis hardwickii* (Miers) size frequency distribution in the commercial catches at Versova from 1957–58 to 1959-60 (After Mohamed, 1967)

fecundity of the species. Based on the analysis of samples obtained from Singapore Strait, Hall (<u>Op. cit.</u>) remarked that the species probably spawns in deeper waters of Singapore Strait in about 40 fathom area possibly twice each year by inference, although, individuals no doubt spawns only once at the end of first year of life or six months later.

In Bombay waters, the breeding period appears to be protracted extending throughout the winter, from October to February with maximum intensity in December and January (Mohamed, 1967a).

<u>Population</u>

<u>Sex ratio</u>:- In Bombay fishery, generally females dominate over the males. The sex-wise size distribution of the species for the years 1957-58 to 1959-60 is given by Mohamed (<u>op. cit.</u>). Wide disparity of sizes of males and females is seen. The females are recorded to a size of 125.0 mm, while the largest size of males seen is only 85.0 mm. In the distribution of sizes, it is also seen that the size range of females begin from the point where the size range of males end, giving a more or less continuous picture when both the sexes are considered together.

<u>Size composition</u>:- The greatest length recorded for the species is 130.0 mm. In the 'Ambai' fishery at Penang, small specimens measuring below 0.5 cm carapace length are obtained from October to middle of January. Large sized prawns appear in July and the majority of the catches of the 'Ambai' fishery are in the size range of 0.5 cm to 2.0 cm carapace length.

In Bombay area (Fig.27) the males are generally smaller in size and in most of the months specimens measuring between 55-65 mm are caught. The small sized females are scarce in the fishery and ~~November to January~~, the majority of females landed during November-January measure 80-90 mm, while in February-April, slightly larger females measuring 90-100 mm predominate.

<u>Recruitment</u>:- In 'Ambai' fishery of Penang, smaller sized prawns enter the fishery in October.

Abundance:- In Bombay area, the species forms 6.97%, 2.75% and 3.93% at Versova, Sassoon Dock and Arnala respectively. According to Hall (op. cit.) the species appear to prefer deeper waters in the Singapore Strait. In the Ambai fishery, this is the most important species accounting for 42.1% of the total numbers.

Fishing methods:- Some types of gears used for *P. sculptilis* are employed for this species.

Fishing season:- In Bombay area, the fishery starts in November and continues upto May, the peak season being November-January. At Sassoon Dock, its peak of abundance is in October-November and at Arnala it is from March to May.

In the 'Ambai' fishery of Penang, the maximum catches are obtained from mid September to end of November and from Mid July to early October.

Catch:- The species forms about 0.6% of the annual prawn landings of India (Mohamed, 1967b). The average annual catch at Versova, Sassoon Dock and Arnala are 221.243, 59.218 and 38.769 m. tons. respectively.

VI GENERA SOLENOCERA LUCAS 1850, ATYPOPENAEUS ALCOCK 1905, HYPPOLYSMATA STIMPSON 1860, PALAEMON WEBER 1795 and ACETES M. EDWARDS 1830

By

M. Mydeen Kunju

(Central Marine Fisheries Research Institute, Mandapam Camp)

VI THE GENERA SOLENOCERA LUCAS 1850, ATYPOPENAEUS ALCOCK 1905, HIPPOLYSMATA STIMPSON 1860, PALAEMON WEBER 1795 AND ACETES MILNE EDWARDS 1830

M. Mydeen Kunju

SOLENOCERA INDICA NATARAJ 1945

Common name

Kolumbi (Marathi).

Diagnostic characters

Carapace smooth and glabrous. Rostrum straight, lanceolate and slightly ascending, reaching to tip of basal segment of antennular peduncle, armed with 9 to 10 teeth on upper margin. Post-rostral carina feeble, becoming distinct towards posterior region of carapace. Orbital angle dentiform. Post-orbital, antennal and hepatic spines small, thin and sharp. No branchiostegal or pterygostomian spine. Cervical groove oblique, deep and broad on sides, continues with that on the other side through very faint notch on post-rostral carina. Branchiostegal sulcus originates from angle of inferiolateral curve and runs backwaters towards posterior border of carapace (fig.28).

Fourth, 5th, 6th and posterior half of 3rd abdominal segments sharply carinated dorsally; carina of 6th segment terminates in spine. A median sternal spine between each pleopod pair, spines decreasing in size from anterior to posterior.

Telson deeply sulcate mid-dorsally on anterior two-thirds; lateral margins devoid of spines; tip pointed and shorter than exopod of uropods.

Antennular peduncle slightly less than half length of carapace including rostrum, and shorter than antennal scale. Antennular flagella each slightly longer than carapace including rostrum; inferior flagellum twice as wide as superior one.

Mandibular palp 2-jointed, basal joint triangular, as long as distal width; distal joint narrow, slightly less than twice as long as basal segment.

Third maxilliped reaches tip of antennular squama; exppod reaches middle of ischium. All legs with slender exopods. Second cheliped reaches tip of antennal scale; 3rd cheliped (the longest) reaches middle of antennules.

The two halves of petasma united anteriorly; each half of 4 lobes fused together posteriorly and free at distal margins. Inner lobe longest, with tips swollen into spongy mass with toothless outer margin; next lobe with angular border, distal portion fringed with a row of recurved spines, hard chitinous angular plate projecting from near tip; 3rd lobe with broadly rounded outer border fringed with row of small recurved spines; 4th lobe lies inside 3rd; thickened circular end curving outwards.

Thelycum consists of hard plate protruding from sternum behind 5th pair of legs, with tubercular projection between bases of legs; pair of closely approximated small knobs originating from sternum between 4th and 5th pairs of legs; hard vertical plate between 4th pair of legs; small inner lobe on coxa of 3rd leg.

Proximal part of appendix masculina with bar-shaped projection on inner surface, convex at apex, directed ventro-laterally; ridge-like elevation on anterior surface.

Cardiac plate armed on inner surface with about 16 pointed spinules arranged in longitudinal series. Cardiac ossicle sub-oval, pterocardiac bar-shaped, prezygocardiac minute and subrectangular, urocardiac with triangular anterior dilatation, zygocardiac with 2 large sharp conical teeth anteriorly and a row of 11 acute long teeth just above upper large tooth, prepyloric with about 10 slender acute teeth on each side. No tooth near anterior end of inner wall of pyloric chamber.

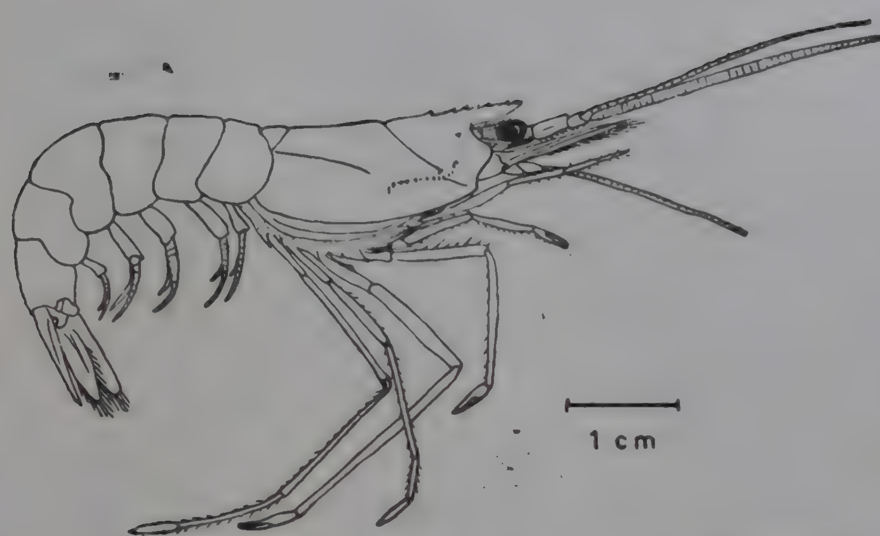

Fig. 28 *Solenocera indica* Nataraj Female (After Kubo 1949)

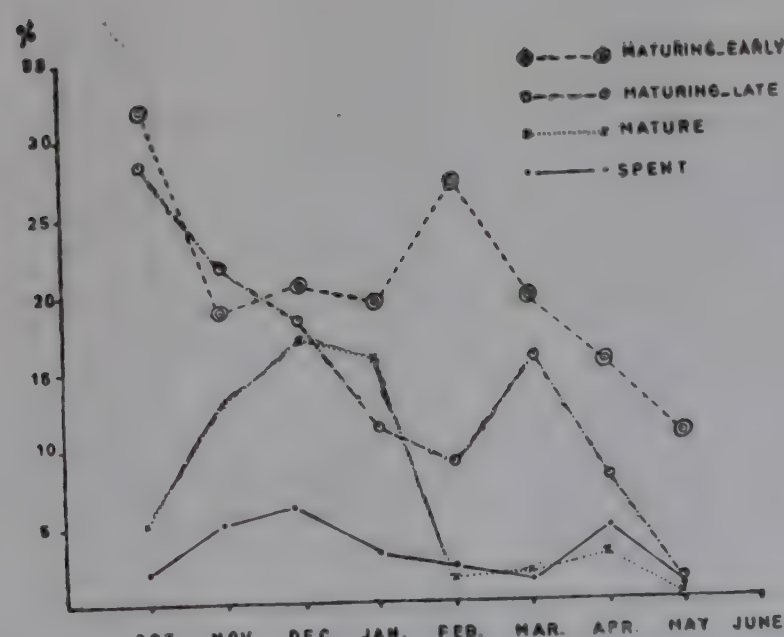

Fig. 29. Incidence of maturity stages of female *Solenocera indica* at Versova (From Kunju 1967)

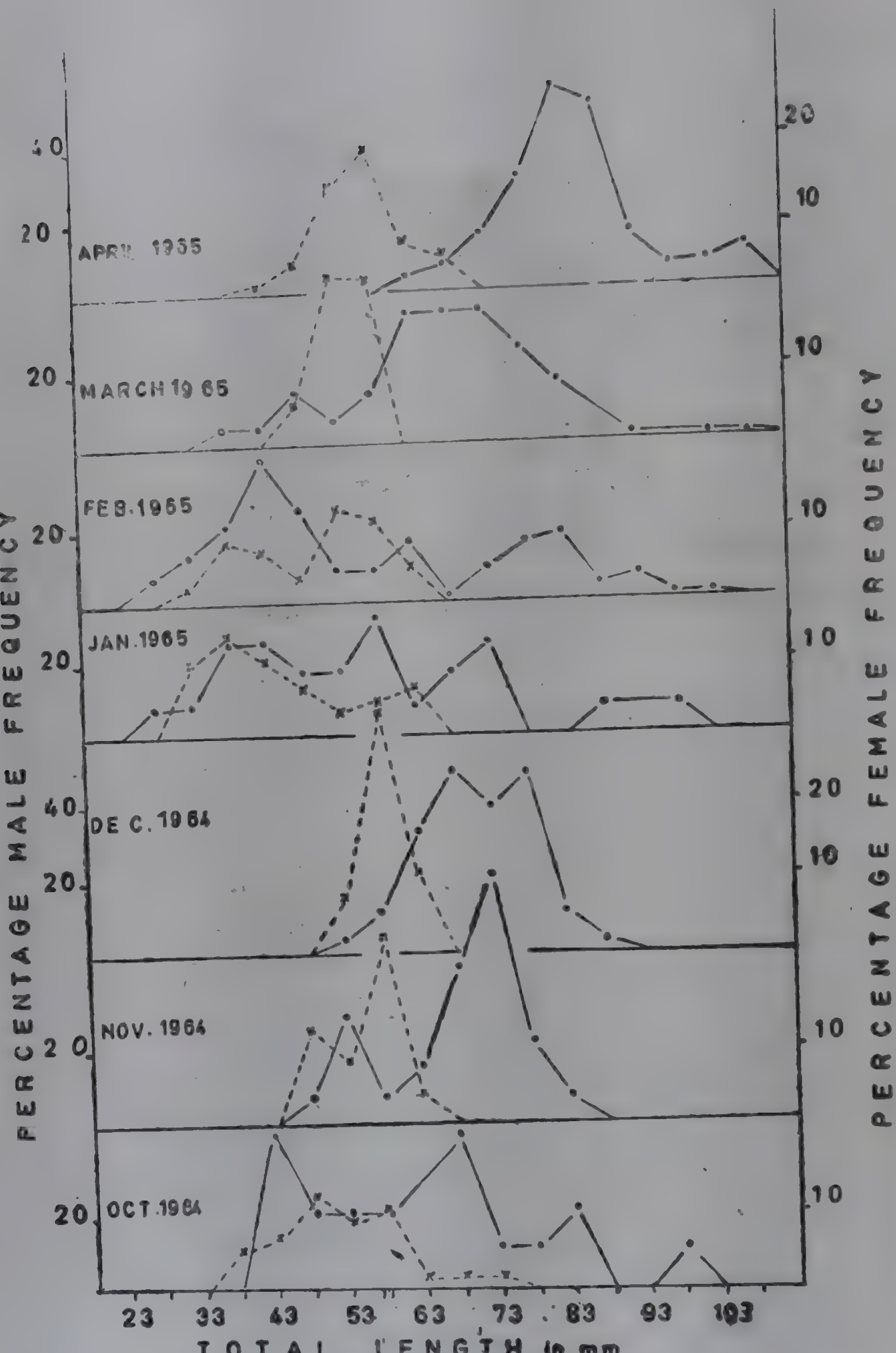

Fig. 30. Length frequency distribution of *Solenocera indica* at Versova. (From Kunju 1967)

Distribution

India, East Pakistan (Ahmad, 1957), Burma (Nataraj, 1945), Singapore and Malaysia (Hall, 1956, 1962); Borneo (Kubo, 1949) and Hong Kong (Cheung, 1960, 1963).

Biology and Life history

Food and feeding:- Crustaceans such as Acetes indicus and Palaemon tenuipes and remains of small fishes constitute the major portion of the diet, both together forming about 67% of the stomach contents of 226 prawns examined from Bombay (Kunju, 1967). Other constituents are polychaetes and molluscs. Sand grains are invariably present in the stomach contents. About 26% of the contents are made up of finely divided unidentified matter, the so-called "detritus", which is considered by some authors as the main food of prawns (Panikkar and Menon, 1956; Dall, 1967). However the preponderance of crustaceans and fishes in the diet may not be the result of passive grazing or scavenging activities alone (Forster, 1951; Kunju, 1956, 1967). Hall (1962) found the prawn mainly feeding on polychaetes in the coasts of Malaysia.

Growth:- Studying the length frequency polygons of the species in the Bombay fishery during the period 1957-60, Mohamed (1967) recorded a monthly growth rate of 4-5 mm. The youngest size groups of this prawn begin to appear in the catches from October-November onwards. The dominant modes for males at 41-50 mm in November 1959 is seen shifting to 76-80 mm by May 1960, showing a growth of about 30 mm in 6 months. In females the mode at ~~617~~ 61-70 mm observed in December is seen shifting to 86-90 mm in 5 months, showing the same rate of growth. With this growth rate he concluded that the entire fishery was constituted by 0-year class of males and 1-year class of females.

As derived from averages of modal progression for a number of years Kunju (1967) arrived at a slightly faster growth rate of 6.96 mm and 6.49 mm per month for females and males respectively in the case of prawns of over 33 mm length. Juvenile prawns of less than 33 mm length (both sexes) may have a faster growth. Taking into consideration these monthly average growth and the approximate age of the juveniles, female prawns of about 110 mm size may be 14 or 15 months old and males of 80mm 9 to 10 months.

Movements:- Two types of migratory movements are discernible, one in connection with spawning and the other in relation to salinity (Kunju, 1967). In the spawning migration the females alone move out of the fishing grounds while the males stay back. How far out they migrate and their further destiny are not known. The population en masse moves offshore when the salinity of the coastal waters decreases from June to nearly October as a result of the southwest monsoon rains.

Reproduction:- Kunju (1967) recognised five maturity stages viz., immature, maturing-early, maturing-late, mature and spent. The distribution of these stages in different months (Fig.29) shows that there is a gradual decline in the incidence of the various stages from October onwards. Among the maturing-early stage there are two peaks in October and February, which are found progressing towards the spawning stage in December and April. The peaks formed by the mature and spent prawns are found in the same period, which indicates that spawning follows soon after the ovary reaches the mature stage.

The immature prawns take about three months to attain the mature condition and eventually spawn. There is a gradual reduction in the relative abundance of prawns in progressive conditions of maturity, from the immature to the spent, the number of spent prawns being conspicuously low, compared to the other stages. Therefore it is possible that the main spawning area may be outside the fishing grounds from where the prawns are studied. Nevertheless, the occurrence of spent prawns in the catches, though not in large numbers, may indicate that the main spawning area is contiguous with the fishing grounds.

As the smallest female found with maturing-early ovary is 51 mm it may attain this stage when it is 5 to 6 months old. Since the immature ovary takes about three months to reach the spawning stage, the species may spawn for the first time when it is 8 to 9 months old. As the life span of the species is about 14 to 15 months it is possible that it may spawn at least once again in its life, but there is no evidence to prove it.

Mating and impregnation take place within the fishing grounds. Females alone move out to deeper waters for spawning.

Females measuring 2.5 to 2.8 cm (carapace length) are found to have 1.36×10^5 to 1.58×10^5 eggs in their ovary, each egg measuring 0.17 to 0.25 mm across (Cheung, 1963).

The breeding season according to Mohamed (1967) is December to May. The peak spawning months recorded by Kunju (1967) are December and April.

Fishery

S. indica occurs all along the coast of India, but is commercially exploited only around Bombay, the fishing lasting from October to May, with peak catches in November.

Females always numerically dominate the population, the female-male ratio being 2:1. The disparity between the sexes is not much apparent up to 48 mm length, but thereafter there is a striking preponderance of males over females. This is probably due to the sexually maturing and mature females moving away from the fishing grounds.

The length frequency distribution of the fishery for a single season from October 1964 to April 1965 is shown in Fig.30.

The largest female and male encountered in Bombay measured 114 mm and 80 mm respectively, and taking into consideration the average monthly growth and the approximate age of juvenile recruits, these prawns are 14 to 15 and 9 to 10 months old respectively.

The fishing grounds of S. indica are close to the shore and not extending beyond 40 metre depth. S. crassicornis (Menon 1940), S. hextii (Wood-Mason & Alcock 1891), S. choprai and S. pectinata (Nataraj 1945) are also recorded from the Indian waters.

Outside India S. indica is of some commercial importance in Hong Kong.

ATYPOPENAEUS STENODACTYLUS (STIMPSON 1860)

Common name

Kolumbi (Marathi).

Diagnostic characters

Carapace smooth without longitudinal or transverse sutures. Rostrum short, slightly surpassing the eye, epigastric tooth placed unusually far back; post-rostral carina runs almost to the posterior border of carapace. Post-ocular and cervical grooves well defined; orbito-antennal not recognisable. Eyes small, with slender stalks. Antennular stalk slender, basal segment having an acute spine. Scaphocerite is as long as antennular peduncle. Antennular flagella long, longer than carapace. Mandibular palp reaches base of carpocerite, basal segment 1.2 times as long as wide. Basal segment of maxillary palp narrowed distally and bears a swollen apex in proximal half. Endopodite of maxilla pointed distally at inner angle. Endopodite of first maxilliped 4-jointed, basal joint with a large setae; exopodite subrhombic in outline. Third maxilliped pediform, extending nearly to the tip of scaphocerite (Fig.31).

First 4 pairs of legs rather short, with the merus and carpus broad and compressed; the 2nd and 3rd chelae with long and slender fingers. Last pair of legs long and slender, about 2 times as long as carapace extending beyond tip of antennal scale by dactylus. All the thoracic legs have slender compressed exopodites.

Abdomen is dorsally carinated from 2nd to 6th somites, but the carination of the 2nd and 3rd indistinct. Telson short, without lateral marginal spines.

Petasma stout, ending in 2 massive cornua directed forwards. Thelycum consists of 2 parts, a long leaf shaped median plate and a pair of slender side plates, proximal end of median plate nearly reaching middle of the base of the 4th thoracic leg.

Cardiac plate bears about 27 spinules. Pterocardiac ossicle bar shaped; prezygocardiac sigmoid, pointed at both inner and outer ends; prepyloric ends in a large median tooth.

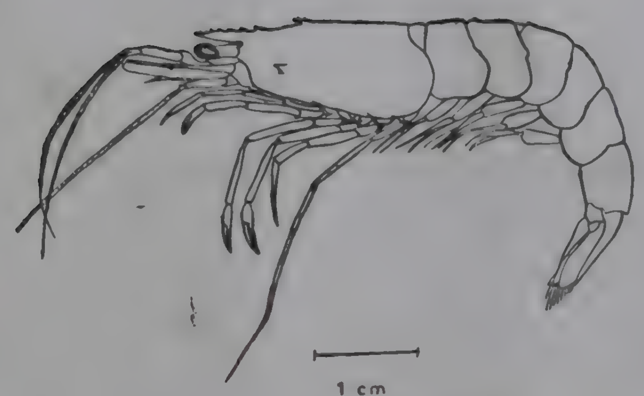

Fig. 31. *Atypopenaeus stenodactylus* (Stimpson) Female (After Kubo 1936)

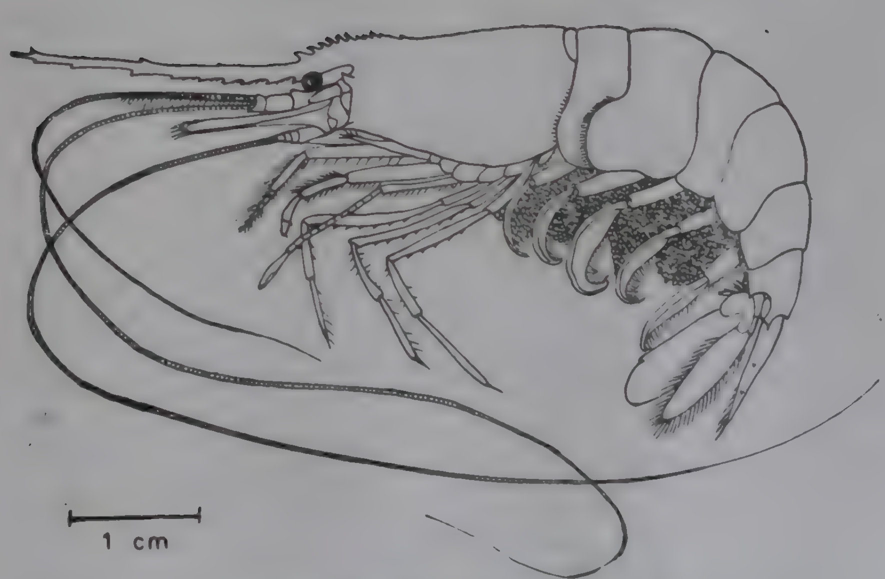

Fig. 32. *Hippolysmata ensirostris* Kemp. Berried female.

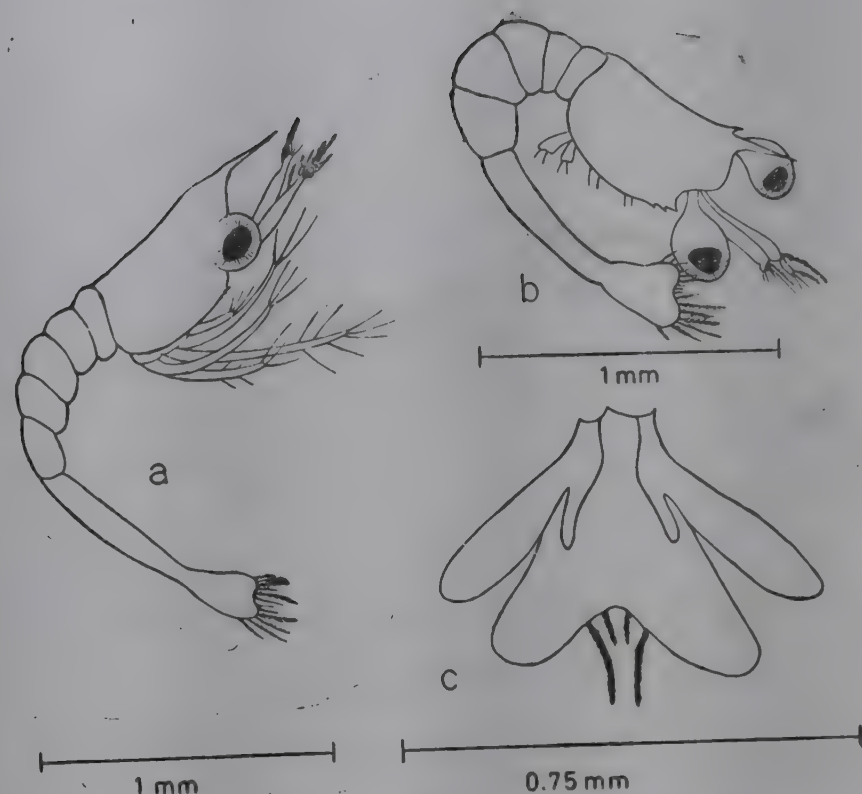

Fig. 33. Early larval stages of *Hippolysmata ensirostris* a, Zoea I; b. Zoea II; c, uropod of Zoea III. (After Bensam and Kartha 1966)

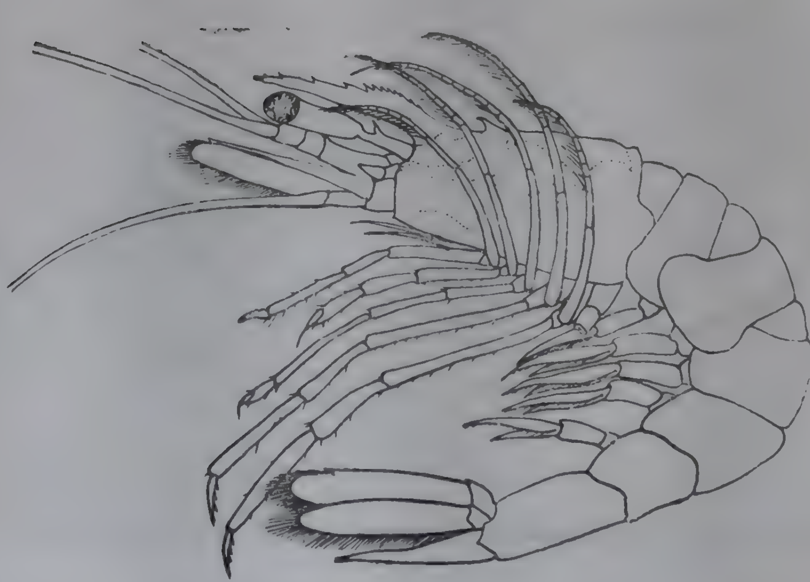

Fig. 34. Late larva of *Hippolysmata ensirostris* (After Kemp 1916)

The characteristic feature of the genus is the presence of pleurobranchia on the 2nd thoracic somite, which is unique in Penaeidae. The genus has only very few species and A. stenodactylus is the only one recorded from India.

Distribution

India, Bay of Bima (de Man, 1911), Seto Island, Sea of Japan (Kubo, 1949), Hong Kong (Cheung, 1960).

Biology and life history

Growth:- Yasuda (1956) observed its growth to some extent in the Seto Inland Sea of Japan. The prawn occurs in the marginal region of the sea close to the shore. The period of appearance of the young prawns is very long from July to January. Those that appear first grow continuously and rapidly to adult size, and then grow at a much reduced rate until the next spawning season. The young prawns appearing in the fishing grounds late in the season do not grow for a limited period and thereafter grow very rapidly before spawning. The life span of the species is less than one year and two or more generations appear in the catches.

Reproduction:- Spawning season in the Seto Inland Sea of Japan is from the last of June to July (Yasuda, 1956). No information is available from Indian waters.

Fishery

Although this species occurs along both the coasts in India it supports a small fishery only off Bombay where it is caught almost throughout the year with peak landings in November-December (Kunju, 1965).

A minor fishery of this has been reported from Kii Channel of the Seto Inland Sea of Japan, where it accounts for 8.6% of the catches (Yasuda, 1956). The genus contains only a small number of species of which one A. formosus is abundant in Queensland (Racek, 1959).

HIPPOLYSMATA ENSIROSTRIS KEMP 1914

Common name

Kolumbi (Marathi).

Diagnostic characters

Carapace a little less than half length of abdomen, exclding telson; pterygostomian spine as large as antennal; rostrum always longer than carapace, with 11-16 dorsal teeth, of which 7-12 are on the elevated crest; inferior margin armed with 7-16 teeth; carapace bluntly carinate mid-dorsally in its anterior half and bears 1 or 2 minute spinules behind basal crest of rostrum (Fig.32).

Antennular peduncle hardly reaches to 2/3 length of antennal scale, the latter variable in form and usually more than thrice as long as broad; flagellum about twice the length of the entire animal.

Mandible without incisor process or palp. Third maxilliped falls short of apex of antennal scale.

Carpus of 1st peraeiopod a little shorter than chela; dactylus scarcely 2/3 length of palm; merus of 2nd peraeiopod indistinctly divided into 7-11 segments, while the carpus is composed of 12-17; palm of chela shorter than last carpal segment. Last 3 pairs of legs have a variable number of spines on the ventral side of merus. Fifth pair of legs extends to 2/3 or 3/4 length of antennal scale; dactylus with a few spinules posteriorly.

Epipods short and rudimentary at base of first 4 pairs of peraeiopods and concealed from view by downward growth of pleurobranchs.

Sixth abdominal somite is ¼ longer than 5th. Telson about twice the length of 6th somite, has 2 pairs of dorsal spinules. It extends beyond distal end of uropods; there are no terminal spinules.

The species is remarkable for its wide range of variation in the diagnostic characters, specially the rostral armature, proportional

length of legs and number of segments in the carpus of the 2nd pair. The structure of the rostrum and the telson and the rudimentary condition of the epipods are peculiar to the species.

Distribution

India, Ceylon and Burma and Sumatra (Kemp, 1914).

Biology and Life history

Eggs and larvae:- Kemp (1916) described its late larva and post-larva from the Orissa coast. Recently Bensam and Kartha (1965) gave an account of the incubating egg and early larval stages from material collected from the inshore areas of Cannanore in Kerala.

The early developing eggs are roughly spherical in shape with an average diameter of 0.427 mm whereas the late ones are slightly elongated and pyriform with diameter of 0.69 mm along the long axis.

Zoea I (Fig.33) is orange red in colour in the thoracic region, losing the coloration frequently and regaining it. It is 2.15 mm long with a 0.22 mm long rostrum. On the antero-lateral margin of the carapace are three minute teeth. Eyes are sessile and telson broad with spines. Cephalic appendages are well developed.

Zoea II (Fig.33) has well developed stalked eyes and an additional spine on either side of the central notch of telson.

Zoea III (Fig.33) has well developed uropods.

The late larva described by Kemp (1916) is so advanced in structure that it may not be the next stage to Zoea III of Bensam and Kartha (loc. cit.). The intermediate stages are not known. The late larva (Fig.34) has a short rostrum bearing dorsal teeth. Carapace, grooved on either side of the mid-dorsal line, is large and procurved. Eye is exceedingly long, eye-stalk having two segments, the proximal one bearing a conspicuous spine. Antenna and antennules are well developed. Third maxilliped and all the peraeiopods except the last bear very long exoposites.

The post larva is 14 mm long. Rostrum is short, not reaching the tip of antennal scale. Peraeiopods are well developed. Apex of telson is comparatively broad with a pair of long spines.

Fishery

The species has some fishery value only in India along the coasts of Gujarat, Maharashtra, Andhra and West Bengal. H. vittata and H. punctata are two other species seldom encountered in the prawn landings.

PALAEMON STYLIFERUS MILNE EDWARDS 1840

Common name

Ambad (Marathi), Ghora chingri (Bengali).

Diagnostic characters:-

Rostrum long, reaching beyond apex of antennal scale by a distance varying from 1/3 to 3/5 of its length; proximal portion strongly elevated dorsally forming a prominent basal crest which bears 5 to 7 teeth; slender in front of the crest and upturned; usually unarmed for the greater of its length, but near the tip as a rule, provided with 1 to 3 small widely separated teeth; lower margin with 6 to 10 teeth (Fig.35).

Antennal spine small and inconspicuous and the branchiostegal much larger, above which is a finely cut groove.

The greatest breadth of the cornea about equal to the length of the eye-stalk. A small ocellus visible partly joined to the cornea.

Basal segment of antennular peduncle with a small spine on the lower surface. Outer border sinuous in front of the short spine representing the lateral process, and terminates in a tooth which extends but little beyond the level of the protruding setose antero-external margin of the segment. The second segment, measured mid-dorsally is a little more than half the length of the third. Total length of the shorter branch of outer antennular flagellum is about equal to that of peduncle.

Antennal scale broad and 3 times as long as wide; the rather sharply rounded distal end of lamella extending much further beyond the spine at the outer margin.

Madibular palp 3 segmented; third maxillipeds reaching about to the end of antennal prduncle; the antepenultimate segment less expanded distally than in P. tenuipes and the exopod reaching to its anterior quarter.

First peraeiopods reach almost to the end of antennal scale. The merus and carpus about equal; chela barely 3/5 the length of carpus. Second peraeiopods vary considerably in length. In large specimens they may extend beyond the tip of the scale by the whole of the chela; carpus and a small portion of the merus; in some, they may reach only by a small fraction of the finger length. Ischium, merus, carpus and palm decreases successively in length in most individuals, but in very large males the carpus sometimes equal to, or a little longer than the merus; carpus always shorter than chela.

Last 3 pairs of legs slender and usually bear short setae on the posterior margin of the ischium, merus, carpus and propodus. Dactylus of 3rd legs less than half the length of propodus and that of 5th legs from 1/3 to 1/4 the length of propodus.

Abdomen smoothly rounded above in small examples, but in those of large size, sometimes a blunt and inconspicuous dorsal ridge extending from the middle of 3rd somite to the end of 6th. Sixth somite, dorsally less than half the length of carapace.

Telson reaches to about 3/4 the length of outer uropod; it bears 2 pairs of minute spinules in its distal half. The apex in large specimens is simply pointed, without trace of lateral spinules; in smaller, but still adult specimens 2 pairs of very small spinules may be found not reaching the tip. Outer uropod is narrow, about 3 times as long as broad.

Specimens from the west coast of India as a rule have the rostrum markedly longer than those from the Bay of Bengal. Young prawns are with shorter rostrum.

Distribution

India, East Pakistan (Ahmad, 1957); Burma (Henderson, 1893); Borneo (Nobili, 1903).

Biology and Life history

Food and feeding:- Crustaceans (Acetes sp., penaeid and palaemonid postlarvae, megalopa larvae of crabs, copepods and mysids) and fish larvae constitute about 32% of the stomach contents of 352 prawns examined from the estuaries of West Bengal (Kunju, 1956). Sand grains are present in more than half the number of prawns and 38.6% of the food is made up of unidentified debris. About one-fourth of these prawns are with empty stomachs. Pillay (1954) stated that the species feeds on microbenthic vegetation and organic detritus in the confined brackish-water bheris of West Bengal.

Growth:- The growth rate appears to be about 3 mm a month during the period of its life in the estuaries in West Bengal (Kunju, 1956).

Movement:- The species is predominantly marine, but is capable of tolerating very low salinities and rarely freshwater conditions (Kemp, 1917a).

Reproduction:- The species migrates seaward from the estuaries at the end of the period of egg-carriage and liberates the young in the sea. The breeding period is long, extending from October to July, with the peak period from April to July. Kemp's (1917a) observation that the species ascends estuaries for breeding is not supported by evidence. Rai (1933) indicated that the species breeds in Bombay in the month of September.

The eggs carried by berried females vary from 1600 to 3800 depending on the size of the prawn. The eggs are carried on non-plumose setae of all but the fifth pleopods. The presence of these setae may be taken as a certain indication that eggs are about to be laid or that young have been hatched, while their absence marks the end of the breeding season. The size of the smallest egg-bearing female is 68 mm and that of the largest is 86 mm in length.

The number of females is always greater than that of males in all the size classes, the overall ratio being 56:44 (Kunju, 1956).

Fishery

The dominant size groups at Port Canning in West Bengal, where the fishery was observed fell under the 45 to 66 mm length range, which formed about 75% of the catches.

Along Maharashtra coast this species formed less than 1% of the prawn landings in 1959-1963, the magnitude of the catches being sizable from June to September.

PALAEMON TENUIPES HENDERSON 1893

Common name

Ambad (Marathi).

Diagnostic characters

Rostrum variable in length, extending beyond the apex of antennal scale by 1/5 to nearly its length. Basal crest well elevated with 5 to 7 teeth, the formmost one not reaching the end of antennular peduncle. In front of basal crest the rostrum trends downards, but before reaching the end of antennular peduncle is reflected strongly upwards and is continued almost in a straight line from this point to the apex. On the dorsal edge, near the tip there is a single tooth. The lower margin is provided with 2 to 6 teeth (Fig.36).

Antennal and branchiostegal spines about equal in length; the latter placed on the extreme frontal margin of the carapace, and not a listtle distance behind it as in some other species of the genus.

Second segment of antennular peduncle measured dorsally is much less than half the length of the third. Short ramus of the outer antennular flagellum reaches barely to the apex of the antennular scale. Basal portion of inner flagellum swollen; antennal scale rather strongly narrowed anteriorly; its length about 3 1/3 of its greatest breadth.

Mandibular palp 3 segmented; third segment scarcely longer than the second. Anterior lobe of epipod of first maxilliped not pointed. The antepenultimate segment of third maxilliped considerably expanded distally.

First peraeiopod reaches a little beyond apex of antennal scale; the carpus about 1½ times the length of chela. Second peraeiopod reaches beyond antennal scale by at least the length of chela; merus longer than carpus; carpus is distinctly shorter than palm and less than half the length of finger; palm strongly swollen, and fingers straight with conspicuously inturned tips. Last three legs of extraordinary length and slenderness and usually found broken in preserved material. The extreme length of these legs is mainly due to the lengthening of the propodus and dactylus; the carpus in all cases short. Third legs at least 2/3 the entire length of the animal; fourth and fifth pairs much longer, considerably exceeding the total length. Dactylus in these legs twice the length of propodus.

Abdomen not dorsally carinate. Pleura of 5th somite narrowed and drawn out posteriorly. Sixth somite dorsally measured, is a trifle more than half the length of carapace. Pleopods exceptionally long, the first pair about 1½ times the length of carapace.

Telson reaches only a little beyond the middle of outer uropod and sometimes bears a pair of small spinules near the distal end. The apex bears a single pair of lateral spinules which extend considerably beyond the rounded median prominance. Outer uropod long and narrow.

In specimens 15-30 mm long the rostrum is very much shorter than in adults, not reaching beyond the middle of the last segment of the antennular peduncle. The last two pairs of peraeiopods are not used for progression and probably they have taken on a sensory function.

Other species of the genus rarely occurring in India are *P. belindae*, *P. debilis*, *P. sewelli* and *P. semmelinkii* all belonging to the subgenus *Palaemon* (Holthuis, 1950).

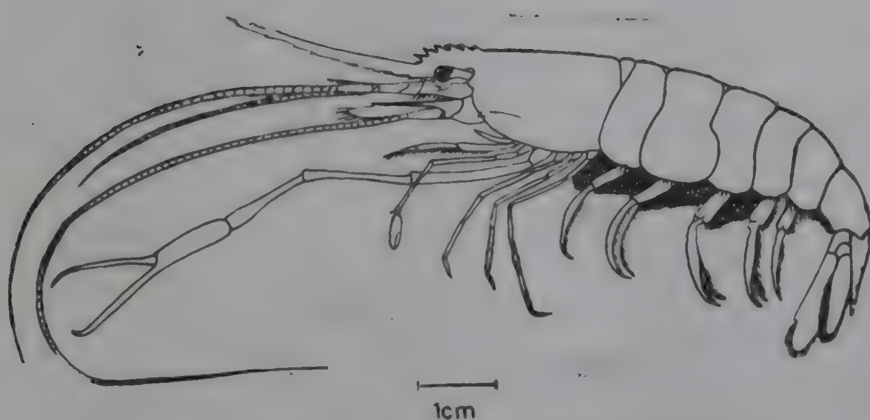

Fig. 35. *Palaemon styliferus* Milne Edwards. Berried female (After Kemp 1917 a).

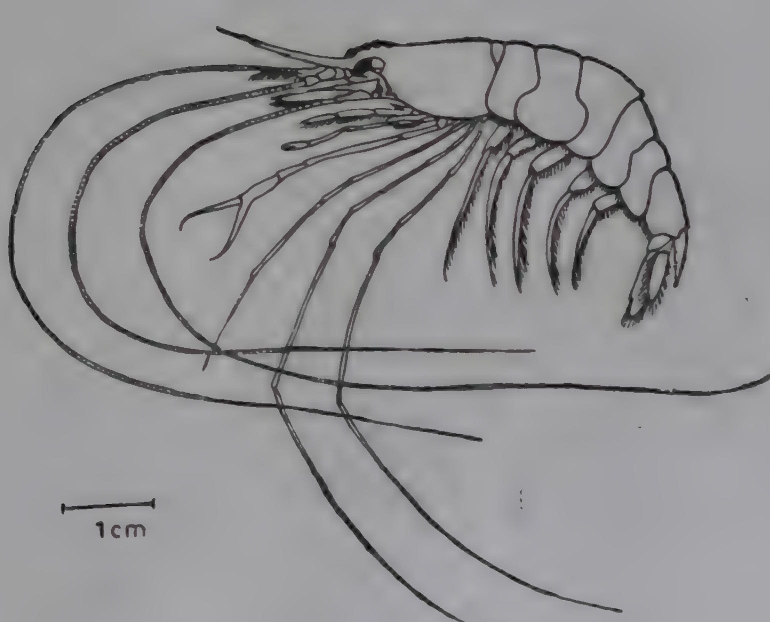

Fig 36 *Palaemon tenuipes* Henderson. Female (After Kemp 1917a)

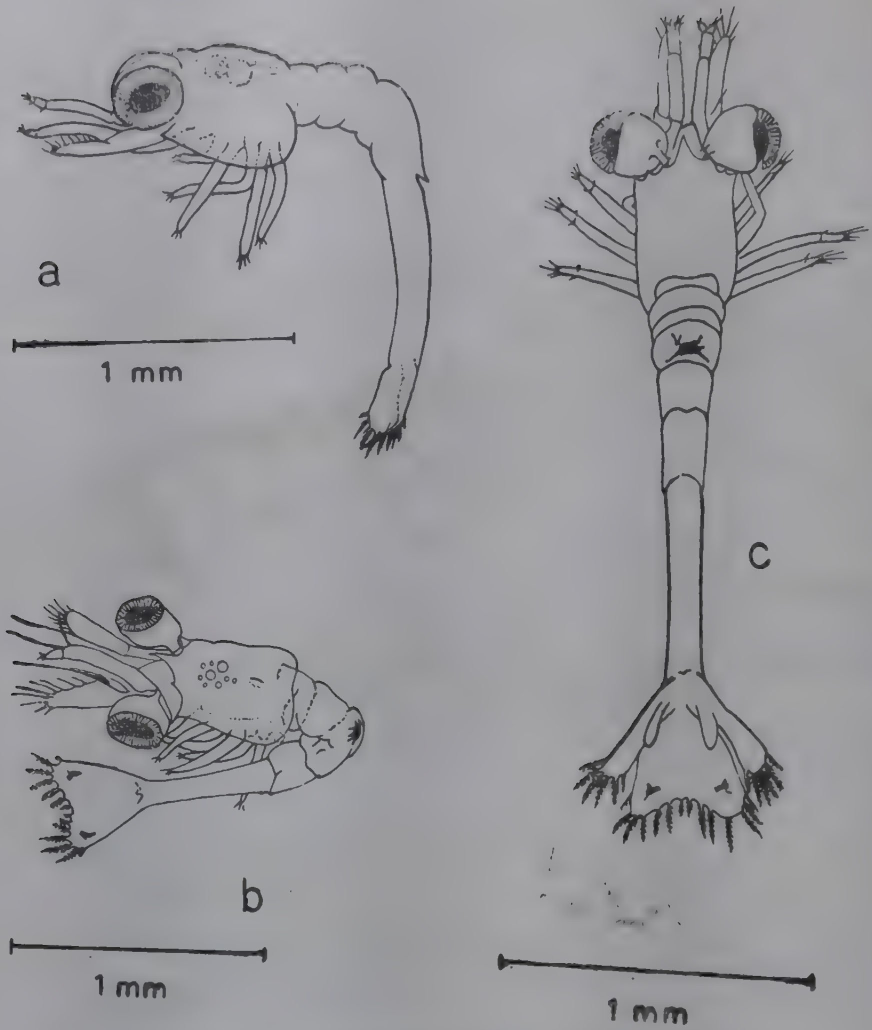

Fig. 37. Early larval stages of *Palaemon tenuipes*. a, Stage I; b, Stage II; c. Stage III; (After Pillai 1966)

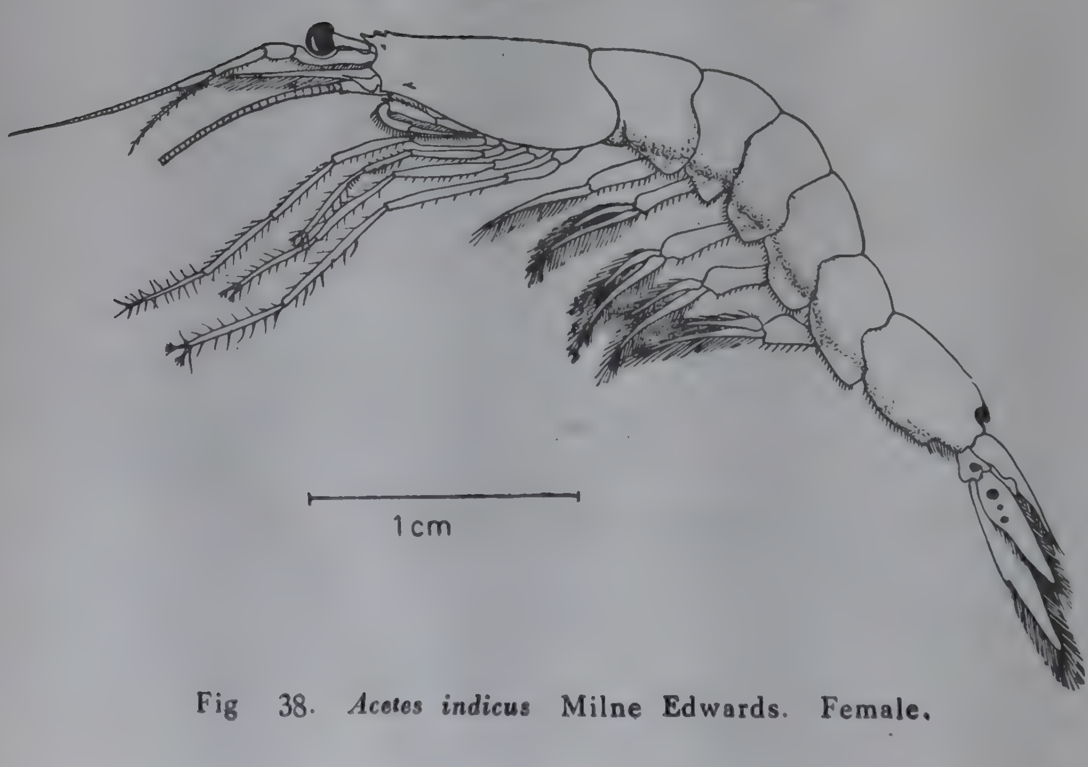

Fig 38. *Acetes indicus* Milne Edwards. Female.

Distribution

India, East Pakistan (Ahmed 1957, Qureshi, 1956), Burma (Henderson, 1893).

Biology and Life history

Eggs and larvae:- The embryonic development and three early larvae were described by Pillai (1966) from material collected from Cannanore in Kerala.

The egg is more or less oval in shape having an average size of 0.52 mm x 0.40 mm. The yolk in the unfertilised egg is granular with very small globules. The central mass in the fertilised egg is dense appearing darker than the peripheral area. The embryonic development was followed by the author till the first larva hatched out on the 14th day after fertilisation. Temperature of the sea water medium was 25.5°C.

Larva-stage I (Fig.37a). Average size was 2.04 mm. the carapace having a small pterygostomian spine, the small rostrum being hidden in between the optic vesicles; eyes bluish black, sessile and prominent. Traces of yolk granules and vacuoles are present.

Larva-stage II (Fig.37b). First moulting after hatching occurred on the next day. The larva measured about 2.21 mm. There are brownish pigments on the eye stalk. Rostrum is pointed and more conspicuous than in the first stage. Eyes are stalked and prominent. Supraorbital and pterygostomian spines are present. Dentition of the mandibles is assymmetrical. First two pairs of peraeiopods are well developed and functional. Telson is not yet differentiated from the last abdominal segment.

Larva-stage III (Fig.37c). The second stage larva moulted on the 4th day after hatching into the third stage. It is 2.45 to 2.53 mm in length. Pink chromatophores are noticed on the posterior region of the carapace. Rostrum is prominent with a single tooth on its dorsal margin. Rudiments of last two pairs of peraeiopods have developed. Telson is differentiated from the last abdominal segment; uropods are developed well.

The larva did not undergo any further development in the laboratory.

Fishery

The species is found all along the Indian coast. It constitutes a minor fishery in the estuarine and foreshore areas of West Bengal and Orissa. It is caught in enormous quantities in Bombay and forms a minor fishery in Gujarat (Ramamurthy 1963). In 1959-1963 period in Maharashtra it formed 32.56% of the prawn landings, about half the annual catch having been accorded in April and May. Several factors such as the forced duration of the tidal currents, the extent of rainfall over the adjoining land mass, the annual cycle of upwelling in the coastal waters and the depth wise distribution of the fishing grounds seem to influence the success or failure of the fishery.

ACETES INDICUS MILNE EDWARDS 1830

Common name

Jawla (Marathi).

Distinguishing characters

Eye longer than in other species and a little more than one-third length of carapace, stalk slender. Basal segment of antennular peduncle of female about the same length as that of the two distal segments combined; in males the 2nd segment more slender than in females; ultimate segment always greatly elongated, much longer than the first (Fig.38).

Outer antennular flagellum of male bears a single large clasping spine, with finely serrate inner margin; on the segment opposite the tip of the spine there is a group of 5-7 close-set spinules.

Third maxilliped reaches a little beyond tip of 3rd peraeiopod, and in female, much beyond end of antennular peduncle. Ultimate segment not divided into sub-segments. Basal segments of 3rd maxilliped and all peraeiopods proportionately stouter than in other species.

Basis of 3rd peraeiopod with a large tooth on the inner margin close to the insertion of ischium, a character not found in other species.

Third thoracic sternite of female very deeply channelled longitudinally, the channel being continued backwards on to the anterior portion of the 4th sternite. The anterior margin of the 3rd sternite is deeply sunk and almost transverse. Behind inner angles of coxae of the 3rd legs there is, on either side, a conspicuous tubercle.

Between the bases of the 1st pleopods in both the sexes, there is a large procurved tooth.

Outer lobe of each half of petasma more or less crescentic in shape with the antero-external border strongly thickened; proximal end of the internal lobe truncated, much expanded externally and bearing a small process at its inner angle. The surface of the distal portion has a sort of honey-combed appearance, due to the presence of numerous small pits, each of which contains a modified hooklet.

Telson reaches well beyond the middle of inner uropod and is rather sharply pointed at the apex. Ciliated and non-ciliated portions of external borders of outer uropods are separated by a prominent tooth.

The genus Acetes is characterised by the absence of the last two pairs of peraeiopods. In distinguishing the species the most important indications are those derived from adult males. Form of the petasma is a most reliable and satisfactory guide, while good characters are also to be obtained from the sexual modifications of the external flagellum of the antennule. Males possess an elongated antennal peduncle (except in A. erythraeus). The red spots on the tail, the so-called "tail-organ" (Okhada, 1928) are not of specific value but they are of generic importance (Nataraj, 1947; Kemp, 1916). They are in two pairs, one pair on each side found in all the species. Their function is not known, but Okada (1928) believes them to be photogenic. The degree of curvature of the tip of the clasping spine on the outer antennular flagellum is of specific importance.

Other species recorded from the coasts of India are _A. erythraeus_ Nobili, _A. japonicus_ Kishinouye, _A. serrulatus_ var. _johni_, _A. sibogae_ Hansen and _A. cochinensis_ Rao (in press).

Distribution

India; Gulf of Siam (Kemp, 1917b).

It is quite common all along the coasts of India and is commercially exploited from the estuaries and onshore areas of West Bengal, coasts of Madras (Jones, 1965) and the northern section of the west coast.

Biology and Life history

Eggs and larvae:- Larval development of an allied species, _A. erythraeus_ was described by Menon (1933). The characters set forth in genital area of the adult female and the uropod of the adult individual in their description and figures resemble those of _A. indicus_. The larvae were collected from the inshore areas of Madras coast.

Movements:- The species of _Acetes_ are usually found gregariously swimming in great numbers in midwater or near the surface. They occur near the shore region in the open sea and are frequently common in estuaries and backwaters. They are often found where the water is of low salinity and occasionally in places where it is quite fresh, but penetrate little, if at all, beyond the reach of tidal influence.

Reproduction:- The breeding season of some allied species, viz., _A. serrulatus_ and _A. erythraeus_ recorded from the Travancore coast (Nataraj, 1947) is from January to April, as seen from the presence of mature gonads. This is further supported by the plankton collections of April to July containing large numbers of _Acetes_ larvae (Menon, 1933). During the breeding season the adults appear in large shoals in coastal waters drifting with the current along with mysids, Alima larvae of _Squilla_ and fish fry. During these months they are invariably found in the stomach contents of different fishes such as _Lactarius_, horse mackerels and _Trichiurus_.

Fishery

The species is common all along the coast of India and is commercially exploited from the estuaries, on shore areas of West Bengal, Coasts of Madras (Jones, 1965) and the northern section of the west coast. In 1959-1963 along the Maharashtra coast it formed about 19% of the prawn landings, the fishery starting from January and lasting up to May.

VII GENUS *MACROBRACHIUM* BATE 1868

By

M.J. George

(Central Marine Fisheries Research Institute, Mandapam Camp)

VII GENUS MACROBRACHIUM BATE 1868

M.J. George

While distributed in most of the Indo-Pacific region the species belonging to this genus mostly inhabit freshwaters. Species like *Macrobrachium rosenbergii*, *M. malcolmsonii*, *M. idae*, *M. mirabile*, *M. rude* etc. however, are distributed in brackishwaters also. According to Tiwari (1955) there are altogether 34 species of this genus recorded from India. Among these, 14 are coastal species, several of which are known to migrate to brackishwater during the breeding season. Rest of them are restricted to freshwaters of the various river systems. Included in the first group are a few species which are commercially important, the most important of which are dealt with in detail below with reference to the existing knowledge about their biology and fishery.

1. MACROBRACHIUM ROSENBERGII (De MAN)

Common name

In Bengal it is commonly known as '*golda chingri*' or '*mocha chingri*'. On the south west coast in Kerala backwaters it is locally called '*aattu konju*'. In Malaya it is known as 'Udang galah'. Vernacular names for this prawn in East Pakistan are Bharo, Chooda, golda, mocha, mora and shala chingri.

Diagnostic features (fig. 39).

Rostrum long and exceeds the antennal squame by narly 1/5 its length, bent near the middle and upturned distally. The tooth formula 12 to 15 (most commonly 12 to 13) dorsally and 10 to 14 (most commonly 11 to 13) ventrally; 7th to 11th teeth are usually separated by wider intervals than others. The first 3 upper teeth, or rarely the first two, are on the carapace. In the female the rostrum is more strongly upturned distally and somewhat less deep.

The large chelipeds are subcylindrical and either equal or subequal; half as long again as the body; a longitudinal pale line traverses the upper and lower surfaces of the palm, carpus, and sometimes the merus. The joints are beset with broad-based spines which are less strongly developed on the ischium and the immobile finger. The distal end of the carpus is about the same width as the palm, while the latter is of uniform width. The finger tips are strongly curved, more especially that of the mobile finger, which is stouter than the immobile finger and densely pubescent, a fact which causes it to look stouter than it really is. The tooth on the immobile finger is conical, while the crenation of the ridge situated posterior to this tooth is well pronounced; the proximal tooth of the mobile finger may, in some cases, be followed by a small tubercle. When the fingers are closed the tooth on the immobile one lies nearer the proximal than the distal tooth on the mobile finger. In the female these chelipeds are more than half the length of the body and beset with feebly developed spines. The palm is slightly compressed dorsoventrally, and is about the width of the distal end of the carpus. The mobile finger is stouter than the immobile, but not to the same extent as in males, nor is it so densely pubescent. When the fingers are closed the distal tooth of the immobile finger lies midway between the two teeth on the mobile finger.

The telson tip is acutely pointed; the inner subterminal spinule on each side projects backwards beyond the outer one, but does not nearly reach the tip of the telson itself.

The whole surface of the body is conspicuously punctate, but this character is less marked on the carapace.

Colouration:- In fresh specimens, especially in males the large chelipeds are deep peacock blue, passing into green on the palm and fingers. This colouration is absent from the coxal and basal joints and is deeper on the upper than on the under surface. The ambulatory legs are pale blue. The spines on the legs are deep blue at the base and orange towards the apex. In ~~the~~ general the body is flesh coloured. The abdominal segments have deep blue transverse bands which are broadest on the 4th, 5th and 6th segments.

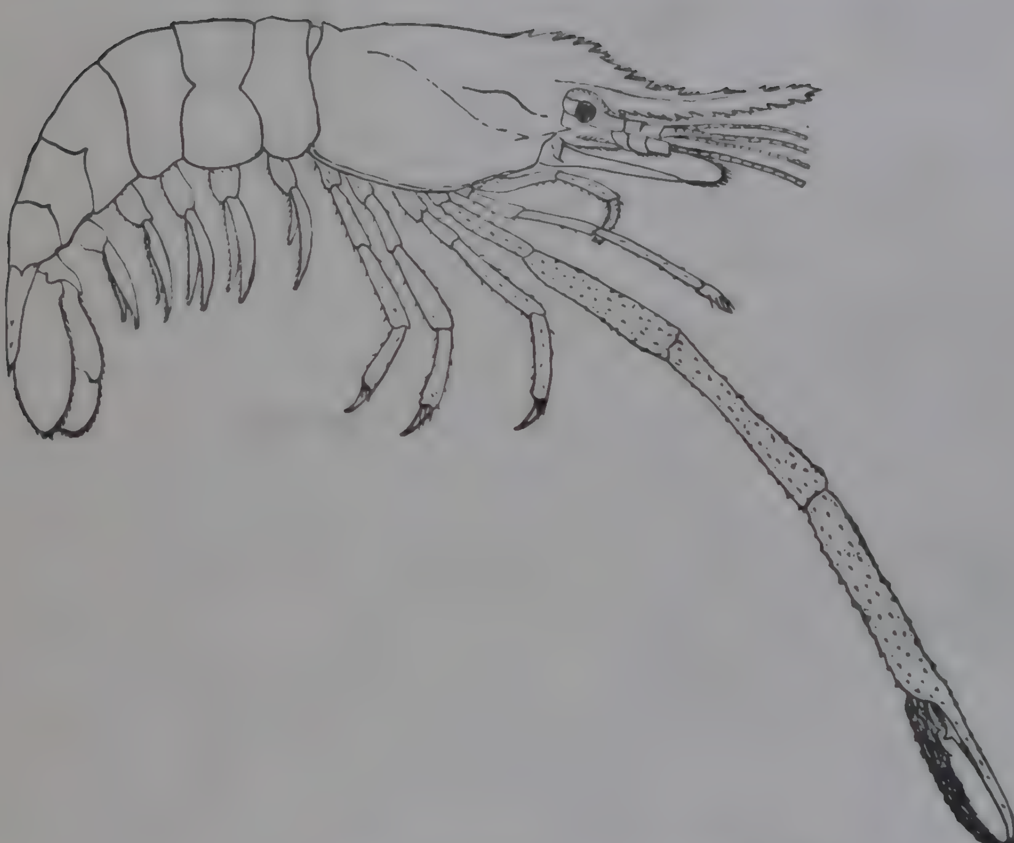

Fig. 39. *Macrobrachium rosenbergii* (de Man)

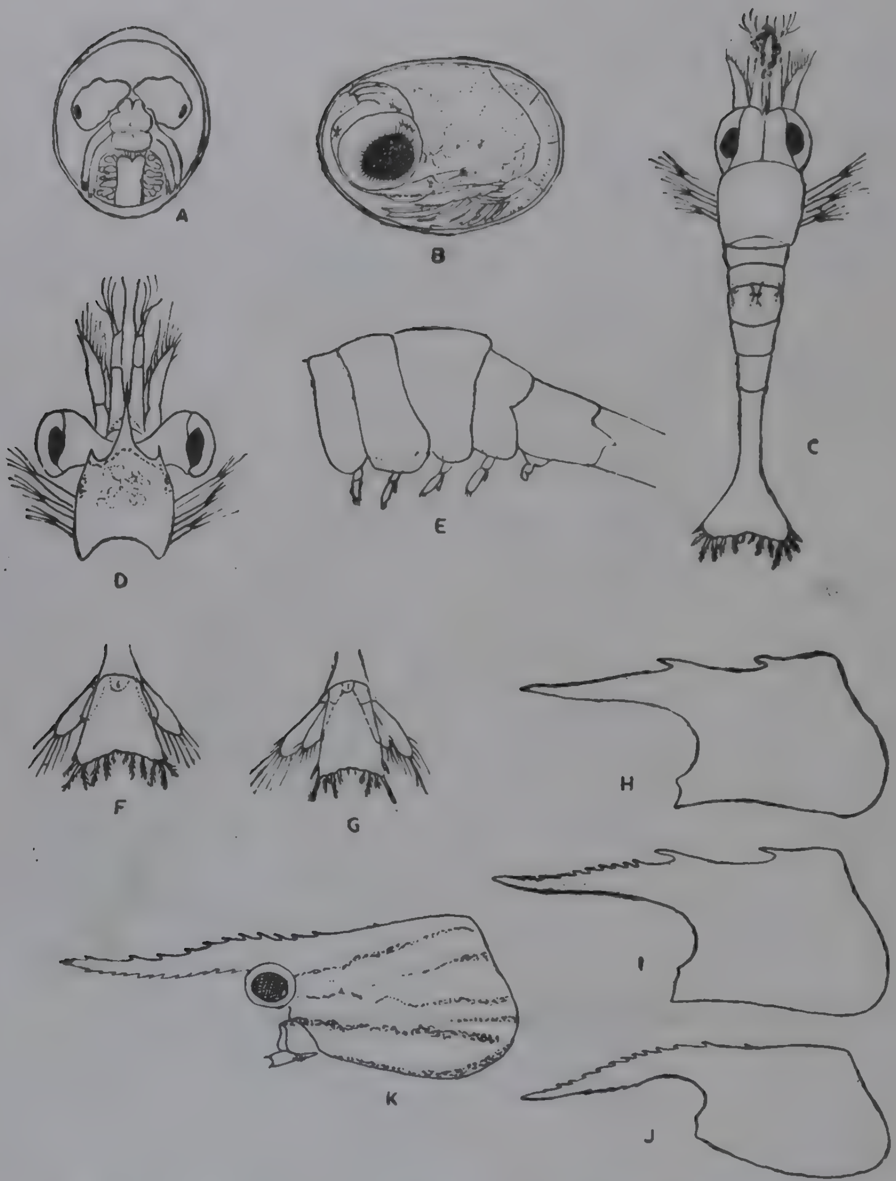

Fig. 40. Egg and larval stages of *M. rosenbergii*
A. B Well developed eggs. C. 1st stage larva
D. Head of 2nd stage larva. E. Body of 9th stage larva
F. 3rd stage larva-tail end
G. 4th stage larva-tail end
H. Carapace-30 days old larva
I. Carapace-12th stage larva
J, K. Carapace-juvenile prawns (Afthe Ling 1962)

Distribution

General distribution:- This species is confined to lower reaches of rivers, jheels etc. and widely distributed in Indo-Pacific zone, the western-most limit of distribution being the Indus delta. It does not extend beyond Indo-China in the Asian mainland. According to the water and land areas code given by Holthuis and Rosa (1965) the distribution of this species in land areas is in 423, 424, 431, 432, 433, 434, 435, 436, 437, 438, 611 and 621. In water areas it is distributed in the regions ISW and ISEW.

In Indian waters it is found to occur along both the coasts, on the west coast from Indus delta to Malabar coast and on the east coast from the south to Mahanadi delta and also in deltaic Bengals. In the backwaters and Pampa river system of Kerala and in the Hooghly estuarine system it supports good fisheries.

Differential distribution:- *M. rosenbergii* forms a considerable fishery in the freshwater zone of the Hooghly estuarine system. In the gradient zone it occurs in much lesser extent and only stray individuals of 0-year have been recorded in the marine zone. Smallest individuals (9 mm to 30 mm total length) are found during May to July months in the upper reaches of Roopnarayan and Hooghly rivers. They occur mostly in shallow canals of the rivers.

In Cochin backwaters in summer months the juveniles are seen concentrating in the deeper areas of Pamba river near Pulikizh and such other places. They come down the river and enter the backwaters with the onset of the monsoon. During the breeding season adults are caught even from near the bar mouth. There are reports of stray specimens caught from the sea just outside the bar mouth.

Life history

Eggs and larvae:- The early larval stages of the species from Cochin backwaters have been described by Menon (1938), obtaining stages I and II in the larval development. In the 1st stage the length of the larva varies from 2.0 mm to 2.25 mm and the 2nd stage larva measures

about 2.5 mm in length. In stage I larva the carapace has a long, slender rostrum which is more than half of the antennular peduncle in length. The anterolateral angles of the carppace are drawn out into small pterygostomian spines. The posterior margin of the telson is slightly concave and bears 7 pairs of spines. The tips of the antennular peduncles and the oral region on the ventral side are beautifully pink in colour. A branching pink chromatophore is present on the dorsal side of the 3rd abdominal somite and another at the base of the telson on the ventral side. The appendages are almost identical with those of the 1st stage of M. rude. The antennular peduncle is unsegmented. Outer antennular flagellum is an unsegmented papilla bearing at its tip 4 aesthetes and a short plumose seta. Antennal peduncle bears a slender pointed spine opposite the base of the flagellum, which is finger-shaped, unsegmented and about 2/3 length of the scale and terminally with a long plumose seta and a spine. Scale is divided distally into four clearly marked joints. Mandible with incisor portion possessing 1 or 2 blunt teeth and ~~the~~ molar portion 2 to 3 minute teeth. Proximal masticatory process of maxilla I narrow and armed with 4 setae at the tip. Distal process has 4 teeth and a short seta. In maxilla II the proximal, larger of the three processes on the protopodite is armed with 4 setae and 3 setae on the others. Endopodite has a basal lobe carrying 2 setae and is tipped with a single seta. Scale has 5 plumose setae along its margin. Maxilliped I has the coxopodite reduced with 2 very short setae and basipodite slightly produced inwards and carrying 4 small setae. Endopodite has 3 terminal setae and a small one on the outer margin. Expodite has 4 plumose setae terminally. In maxilliped II the coxopodite is unarmed and the basipodite has a single seta. Endopodite is 4 segmented with the last segment having 3 unequal setae terminally and a small one at the base of the outer margin. Endopodite has 6 setae, 4 large and 2 small. Maxilliped III is similar to maxilliped II, excepting for the presence of 2 setae on the third segment of the endopodite. Behind the maxillipeds there are large biramous rudiments of the first two pereopods.

The second stage larva is also similar to that of M. rude. In addition to the rostrum and pterygostomial spines the carpace bears a pair of supraorbital spines and a median papilla behind the rostrum.

5th abdominal somite has a pair of lateral spines. Posterior margin of telson with 8 pairs of spines, the innermost pair extremely small. Besides the chromatophores of the 1st stage the posterior side of the base of the optic stalks and the protopodites of the first two pairs of maxillipeds are also coloured pink. 3rd abdominal segment has two large branching chromatophores on the dorsal side, each of which sends off a branch into the second segment. The base of the antennal peduncle also has a small chromatophore. All the chromatophores are pink in colour. In addition to the changes in the number of setae on most of the appendages, the first two pairs of pereopods are present with well developed exopodites and endopodites. The endopodite is 5-segmented. Behind the second pereopod there are rudiments of two of the remaining appendages.

Ling and Merican (1961) and Ling (1962) have described the larval development of the species from Malaya. Especially Ling (1962 and 1963) has traced the complete development in laboratory tanks. According to him the eggs (Fig 40) are slightly oval in shape, measuring about 0.6 to 0.7 mm in its long axis and bright orange in colour. The female prawn carries the brood of eggs and takes care of them until they hatch. During the whole incubation period, which is about 19 days at room temperature, the pleopods beat back and forth intermittently to provide aeration for the eggs. Dead eggs and foreign materail are carefully and cleverly removed from time to time by the sensitive and versatile first pair of thoracic legs. Starting from the 12th day of incubation the bright orange colour of the eggs gradually becomes lighter and in its place a light grey colour slowly developed. The light grey colour deepens gradually until the 18th day of incubation, when the larvae inside the eggs are fully developed and the colour becomes slate grey.

The process of hatching starts with slow but continuous vibration of the mouthparts of the larvae, accompanied by some stretching of its rolled up body, forcing the eggs to elongate gradually. Vibration of mouthparts becomes more and more vigorous, accompanied by further stretching of the body. About an hour later the thoracic appendages start to vibrate vigorously but intermittently for about 10 minutes with increasing length of period of vibration. The vibration then becomes very vigorous and continuous. The body continues to stretch and the telson

starts pushing outwards. Suddenly the egg shell breaks and the telson thrush out, followed by the head, and with a forceful flex and stretch of the body the entire larva springs out of the shell. In less than 5 minutes the newly hatched larva starts swimming around actively.

All larval stages are active and planktonic in habit. They swim actively all the time at a slightly oblique angle, with tail first and ventral side upwards. The characters of larval stages (Ling 1963) are:-

1st stage - (1st-2nd day after hatching) Eyes sessile; telson triangular, fan-shaped, carrying 7 pairs of spines; uropods absent.

2nd stage - (2nd-4th day) Eyes stalked; telson triangular, carrying 8 pairs of spines; uropods absent.

3rd stage - (4th-7th day) Uropods present; expodite with 6 spines, endopodite bare.

4th stage - (7th-12th day) Telson oblong, almost rectangular, carrying 6 pairs of spines; uropods with spines on both exopodite and endopodite.

5th stage - (12th-16th day) Telson with posterior margin narrower than the base, number of spines on uropods increased; red, blue and yellowish chromatophores present on 2nd thoracic legs.

6th stage - (15th-21st day) Telson further elongated and narrowed; chromatophores on the 2nd thoracic legs very prominent.

7th stage - (18th-24th day) Buds of pleopods appear; chromatophore mass on mid-ventral abdominal region present.

8th stage - (22nd-28th day) Pleopods biramous but bare; chromatophore mass on mid-ventral abdominal region very prominent.

9th stage - (25th-31st day) Pleopods fully developed with setae.

10th stage - (28th-33rd day) 1st and 2nd thoracic legs chelate.

11th stage - (31st-37th day) Rostrum with 2-3 small teeth on its distal upper margin.

12th stage - (35th-41st day) Rostrum toothed on half of its upper margin.

13th stage - (38th-45th day) Rostrum toothed on its entire upper margin. The larvae are fully grown at this stage and are ready to transform into juveniles.

Juveniles as soon as they are transformed lose all the larval pelagic characteristics, becomes crawlers and settle down to the bottom or cling on to the side of the rearing tank or submerged objects. Raman (1967)

expressed the view that it is possible that the larvae after the early stages leave the planktonic habit and settles to the bottom. A nursery ground for the juveniles was located by him in the upper reaches of Pampa river and suggested the possibility of the existence of several such grounds in the upper reaches of the river system.

Nutrition and growth:- Several authors who studied the feeding habits of *M. rosenbergii* have described it as omnivorous. Mary John (1957) reported about the omnivorous food habit of the species and found that specimens from paddy fields had paddy grains in their stomachs. Raman (1967) observed it to be a bottom feeder and an omnivore. Few stomachs of drag net catches observed by him were found to contain bottom debris and mud with large quantities of decaying organic matter. Fish scales and remains of fish were also present in a few instances. Based on the examination of stomach contents of 396 specimens Rao (1967) is also of opinion that the animal is a bottom feeder and omnivorous. The principal items of food are debris, sand and crustacean remnants. Molluscan remains, filamentous algae, plant and animal tissues are other items of food. Earlier Rao (1965) observed in rearing experiments that the species relished a variety of food items of both animal and plant origin. He even noticed the cannibalistic tendency, eating its own moult and dead eggs. Seasonal variations in feed also was studied by him in 1967 and the data given is reproduced in table I.

TABLE I

Percentage prevalence of various items of food and condition of feed

Item	Jan. %	Feb. %	Mar. %	Apr. %	May %	June %	July %	Aug. %	Sep. %	Oct. %	Nov. %	Dec. %	All months pooled %
Debris	26.23	36.21	..	36.67	31.25	..	..	..	33.90	..	33.33	..	32.64
Sand	26.23	20.69	..	30.00	18.75	..	..	..	32.20	..	26.67	..	26.36
Molluscan remains	1.64	13.79	..	..	..	..	..	..	3.39	..	..	..	4.60
Crustacean remains	16.39	5.17	..	6.67	12.50	..	..	..	15.25	..	13.33	..	11.72
Filamentous algae	11.47	13.79	..	10.00	..	..	..	..	..	..	..	..	7.53
Diatoms	..	..	..	..	..	..	..	..	1.79	..	6.67	..	0.84
Fat globules	6.56	..	..	3.33	12.50	..	..	..	..	..	..	..	2.93

TABLE I (contd.)

Plant tissue	3.24	10.34	..	..	13.33	..	..	..	11.86	..	20.00	..	9.20
Fish remains	1.64	..	..	..	6.25	..	..	..	..	..	..	..	0.84
Animal tissue	1.64	..	..	..	12.50	..	..	..	1.70	..	..	..	1.67
Miscellaneous	4.92	..	..	..	6.25	..	..	..	..	..	..	..	1.67
Condition of feed	60.00	42.86	..	23.27	12.12	..	..	..	24.39	..	9.09	..	

The condition of feed was high during January to April and in September. The immature specimens were mostly found with empty stomachs.

Ling (1962) also considers the prawn omnivorous. Common items of food according to him include aquatic worms, aquatic insects and insect larvae, small molluscs and crustaceans, flesh and offals of fish and other animals, grains seeds, nuts, fruits, algae and tender leaves of stems of aquatic plants etc. When sufficiently hungry it may even become cannibalistic. Food materials are located by the sense of touch. Pieces of food are picked up and brought to its mouth by 1st and 2nd pairs of thoracic legs.

Among freshwater prawns this species grows to the largest size. As reviewed by Bhimachar (1965), Rajyalakshmi (1962) has investigated the age and growth of this species occurring in the hooghly estuary. According to them growth in the species is one of inverse exponential pattern. Males have been estimated to attain lengths of 107.0 and 149.0 mm at the end of the first and second years of life and females 82.5, 130.5 and 168.5 mm at the end of 1st, 2nd and 3rd years respectively. Thus sexual dimorphism in growth is exhibited in this species. Initially the males grow faster than females, but the rate of growth between the 1st and 2nd year appears to be slightly faster in females than in males. At given ages the males are invariably longer than females. The data given by her for the males is shown in Table II.

TABLE II

Results of analysis of size frequency distributions by the probability paper in M. rosenbergii

Age in years	0	I	II	III	IV
	79.5	107.5	149.0	..	..
1959	..	104.5	151.0	181.0	217.5
1960	..	111.5	142.7	176.1	204.5
1961	..	113.7	147.9	..	..
Average	79.5	109.18	147.65	178.55	211.0
Increment in length		38.4	30.9	32.5	

From the same estuarine system Rao (1967) studied the growth of the species by the same method and his results are tabulated below.

TABLE III

Results of analysis of size frequency distribution by the use of probability paper

Calender year	Males Modal length (T.L.) in mm at years				Females Modal Length(T.L) in mm at years			
	I	II	III	IV	I	II	III	IV
1963 (s.d)	108.5 (26.63)	146.5 (18.43)	223.0 (42.10)	..	77.5 (15.87)	133.5 (15.74)	153.0 (18.50)	210.0 (5.78)
1964 (s.d)	123.5 (14.39)	142.5 (19.97)	..	..	89.0 (12.37)	129.5 (14.79)	161.0 (25.89)	220.5 (18.56)
1965 (s.d)	109.0 (10.89)	137.0 (17.89)	229.0 (13.18)	261.0 (11.84)	..	118.0 (15.6)	159.0 (40.35)	232.5 (18.29)
Mean	113.67	142.0	226.0	261.0	83.25	127.0	157.67	221.0

He found 4 normal curves for both the sexes in the size frequency distributions, first of which being 113.67 mm (total length) in males and 83.25 mm (total length) in females. Laboratory rearing experiments also showed more or less the same growth rate and length attained after growth for one year was found to be similar. So these modal lengths were assigned to age

one year. Subsequent modal lengths as shown in table III were designated as of II, III and IV years respectively. Growth rates during the winter months November to February are slower compared to the other months, probably associated with low temperatures during the period. This rate of growth appears to be quite slow.

Raman (1967)stydying the biology of the species from central Kerala waters during the years 1959-63 records a much faster growth rate. Using length frequency data from various centres of observations along the Pamba river system he concluded that females attain 180-200 mm in one year. Males are found to grow slightly faster than females. Among females one-year classes are very rare whereas among males they are common. Females, ar not usually found surviving far into the second year of life. In the case of males the modal size at 141-160 mm when the fishery commences in March at Ramankari moves to 161-180 mm by May, after which growth appears to be faster. From June to October the males grow about 80 mm, an average of 20 mm per month. But during the off season at the river centres the growth is comparatively slow. Dominant size groups at two observation centres for the year 1960-63 given by him are reproduced in Table III.

TABLE III

Dominant size groups of *M. rosenbergii* at Kumarakom and Ramankari for the years 1960-63.

Month	1960		1961		1962		1963	
	Male	Female	Male	Female	Male	Female	Male	Female
At Kumarakom								
June	221-240	161-180 & 221-240	181-200	141-160	..	..	..	..
July	201-220 &241-260	181-200	201-220 &241-260	181-200	261-280	181-200	201-220	181-200
August	221-240	201-220	221-240 &261-280	201-220	261-280	201-220	241-260	201-220
Sep.	..	..	261-280	201-220	281-300	..	221-240	221-240
Oct.	261-280	201-220	261-280	221-240	261-280	221-240	..	..
Nov.	..	..	..	..	281-300	221-240	..	..

TABLE III (Contd.)

At Ramankari								
March	..	..	141-160	101-120	..	..	..	..
April	..	..	141-160	121-140	..	..	121-140	101-120
May	201-220	161-180	161-180& 221-240	121-140	..	..	..	..
June	181-200	141-160	181-200	141-160	161-180& 201-220	181-200	201-220	141-160
July	201-220	161-180	201-220& 261-280	161-180	..	..	221-240	181-200
August	221-240	181-200	201-220& 241-260	181-200	..	..	221-240	181-200
Sep.	241-260	181-200	141-160& 261-280	221-240	..	..	241-260	201-220
Oct.	261-280	201-220	141-160& 261-280	201-220	261-280	221-240	..	..
Nov.	..	..	..	..	..	..	261-280	..

According to him a few males which probably remain upstream during the early monsoon season come down only in September-October. These are stunted in their growth because of their larger sojourn at the upper reaches of the river. The growth rate to a large extent appears to depend on area inhabited, being slow up the river and fast in the backwaters. During the monsoon the growth appears to be very fast in the backwaters and this may probably be due to the flooding of paddy fields and availability of good quantities of food.

Growth being accomplished by a series of moults in this prawn as in other Crustaceans, Ling (1962) has described the process of moulting in this species. Moulting periodicity was studied by Raman (1967) and he found that moulting takes place at irregular intervals, roughly one moult for every 10 mm of growth.

Fluctuations in condition factor 'Kn' was studied by Rao (1967). Based on the fact that a study of relative condition might give an idea of the average number of moultings takingplace in a year he concluded that males moult 6 times and females 5 times in a year in the case of immature

prawns of total length above 30 mm. Sex dimorphism in growth rates involving higher growth for males may probably be due to 6 moults in a year for males and a lower growth in females as a consequence of 5 moults. In mature prawns both the sexes show the highest 'Kn' values during the months March to May which is the peak of the breeding season.

Behaviour and movements:- According to Rao (1969) the extreme limits of salinity tolerance for the species in the Hooghly estuary is 0 to 16.0 °/oo. Spawning behaviour of the species was studied in the laboratory by Rao (1965). Various behaviour patterns in connection with mating and spawning are described by him. It is observed that courting behaviour in males is released only when a female which had just completed pre-spawning moult is available in the vicinity. The behaviour aspects of mating follow in a definite chronological order - fight for the establishment of territory, beconing, courtship, mounting, sex-arousal and copula - in a sequential stereotyped fashion. Ling (1963) is of opinion that soon after the pre-mating moult the female prawn secretes a certain kind of substance which strongly attracts the male. Sexual fighting between the males is a feature noticed in laboratory experiments. The victorious male chases the vanquished and protects the female by arresting it within the range of its long chelipeds. The male mounts the female during copulation and extrusion of eggs on to the pleopods takes ~~pla~~ place generally 8 to 12 hours after mating. Homosexual behaviour was also noticed in males.

Mary John (1957) observed that when migration is obstructed the parent detaches the eggs from the brood pouch and eats them, However, no such observation was made by Rao in his studies. But detaching of eggs, though not of eating them, was observed when sudden fluctuations in salinity and oxygen take place or when the parent is handled by the observer.

M. rosenbergii performs an interesting spawning migration. Generally an inhabitant of freshwaters, this species migrates down to the estuarine regions and spawns in areas where salinity fluctuates between 5.0 to 20.0°/oo. After the young ones grow to a size of 2.0 to 3.0 cm. they migrate up the estuary to the freshwater habitats. The spawning

periods being different in the Hooghly estuary and Kerala backwaters, these movements up and down the river systems and the brackishwater areas takes place at different times of the year in the two different places. A point of interest that emerges from studies at the two different places is that while migration of adults into backwaters in Kerala region takes place at a time when salinity is on the decrease in that area, in the Hooghly region actual migration occurs when the salinity is on the increase in the winter and summer months. The return migration of adults into freshwaters in Kerala coincides with the increase in salinity in backwaters, whereas in the Hooghly the return migration takes place during the monsoon months when salinity is on the decrease. The inward migration of young ones also takes place at different times in the two places.

According to Raman (1967) juveniles and large males seem to be quite at home at the river mouths adjacent to the backwater even when the salinity is nearly 18.0 ‰ indicating that salinity alone is not the inducing factor for them to move up the river. Probably temperature is an important factor influencing their movements. Mary John (1957) observed the optimum temperature for its normal activity to be 29° to 34° C. At the height of the summer they are probably going up the rivers and remaining in deeper basins of the river systems, where the bottom is slushy with plenty of organic detritus. When it rains occasionally during the dry months large numbers of them come down to the backwater regions.

<u>Reproduction</u>:- Male prawns are considerably larger than females, with a pair of extremely long and rather thick legs (2nd pereopods), a big head, a compact abdomen with very little space between its pleurae and with its genital pore at the base of the 5th pereopods. Famales are in general smaller, with shorter and slendere ~~and~~ 2nd pereopods, a medium head, a spacious chamber (brood chamber) on the ventral aspect of the ~~x~~ abdomen, formed by the pleurae and with the genital pores at the base of the 3rd pereopods.

The ovary in immature specimens appear as narrow, transparent or whitish strands. Along ~~the~~ with maturation yellow dots gradually appear on the surface of the ovaries. In mature specimens the ovary is bright

orange in colour and more massive occupying a large part of the cephalothorax just behind the rostral base extending backwards even into the first abdominal segment and could be easily made out.

For maturation of ovary and spawning the species seem to congregate at the middle zone of the Hooghly estuary (Rajyalakshmi 1961). The gonad begins to mature from December-January, more frequently from early February. The posterior part assumes a little yellow colour and yolk granules appear in the oocytes. Gradually the ovary expands and begins to cover the posterior part of the stomach at first, finally occupying the entire cavity underneath carapace. The colour becomes deeper. The immature or first stage ova are very transparent with a large nucleus in the centre. The ripe ova are very opaque. The ova-diameter frequency polygons are given by Rajyalakshmi (1961).

In Kerala estuary when the fishery commences in May-June practically all the females are either immature or maturing. Mature females generally begin to appear from July onwards. By October most of them are either mature or berried. In males the testes are well developed in most of the specimens at this time. Fully grown spermatozoea are observed in specimens measuring 150 mm and above. Mature males are able to mate at any time, while females are ready to respond only after the premating (puberty) moulting.

Mating can be induced under controlled conditions by introducing a matured male and a mature female which has just completed premating moult in an aquarium tank. For mating behaviour see Behaviour and movement, section. Courting behaviour is described by Ling (1963) also. The courting act continues for about 10 minutes to half an hour before the female is successfully won over. The male then holds the female between its long pincer legs and at the same time actively cleaning the ventral portion of her thoracic shell with its other legs. This is followed by the final mating act which lasts only for a few seconds. Sperm ejected by the male is deposited in one mass on the female's ventral thoracic region between her thoracic legs, and is coated with a thin layer of gelatinous substance for protection.

The process of egg-laying may take place about 6-20 hours after mating. Unmated ripe female prawn would also lay eggs within 24 hours after her permating moult, but the eggs would drop off in 2-3 days because they are not fertilized. During egg-laying the body of the female prawn bends forward far enough to have close contact with the ventral thoracic region, so that eggs are extruded through the female genital pores directly into the brood chamber. The eggs are held in bundles like grapes by some extremely thin and elastic membraneous substance. The eggs bundles are adhered tightly to the fine ovigerous setae of the first four pairs of pleopods.

Fecundity of the species has been studied by several authors and the results obtained by these different authors are summarised in Table IV.

TABLE IV

Fecundity in Macrobrachium rosenbergii

Author	Fecundity
Mary John (1957)	100,000 to 160,000 eggs
Rajyalakshmi (1961)	7,000 to 111,400 eggs Log F = 2.7949 + 3.3209 Log L.
Ling (1963)	70,000 to 120,000 eggs
Raman (1967)	139,600 to 503,000 eggs

The number of eggs in a fully mature ovary of a specimen measuring 241 mm was found by Raman (1967) to be 228,850. Rajyalakshmi (1961) observed that the relationship between size (length) of the parent and the fecundity is exponential in the arithmetic form. The value of the exponent was estimated to be 3.3 indicating that fecundity increases more rapidly than body weight in relation to length.

Ling (1963) found that females kept in the laboratory were able to lay eggs twice within 5 months. In his opinion the species may be able to lay eggs 3 or 4 times in one year under natural conditions.

The female prawn carries her brood of eggs and takes care of them until they hatch. Vigorous movements of pleopods back and forth to provide aeration for the eggs is noticed throughout the incubation period, which is 20-21 days according to Mary John (1957), about 19 days (Ling 1963) and 19-20 days (Rao 1965). Dead eggs and foreign material are carefully removed from time to time by the 1st pair of thoracic legs. Starting from 12th day of incubation the bright orange colour of the eggs gradually becomes lighter ~~tha~~ and becomes light grey. This light grey colour deepens gradually day by day until the 18th day of incubation when the larvae inside the eggs are fully developed and the colour becomes slate grey.

Fertilization takes place soon after the eggs are extruded. First division of nucleus occurs about 4 hours after fertilization. Subsequent division of nuclei takes place at about 1 to 2 hours intervals. Cleavage is completed within 24 hours. Ventral plate is formed at the end of the 2nd day. Buds of appendages are well formed during the 4th day. Optic vesicles are formed during the 7th day and eye pigments start appearing during the end of the 8th day. On the 10th day chromatophores are developed. The heart also is formed on this day and it starts beating. The embryo is well formed by the 12th day and almost ready for hatching by 16-17th day. Hatching takes place by the 19-20th day.

The process of hatching starts with slow but continuous vibration of the mouthparts of the larva, accompanied by some stretching of its rolled up body, forcing the eggs to elongate gradually. Vibration of mouthparts becomes more and more vigorous, accompanied by further stretching of the body. After that the thoracic legs start vibration, at first intermittantly and later continuous. The body continues to stretch and the telson starts pushing outward. Suddenly the egg shell breaks and the telson thrush out, followed by the head. With a forceful flex and stretch of the body the entire larva springs out of the shell. In less than 5 minutes the newly hatched larva starts swimming around actively.

The species has a restricted spawning season during the summer months December to July in the Hooghly estuary and according to Rajyalakshmi (1961 & 1964) peak spawning is during March to May. Rao (1967)

confirmed the observation on peak spawning period and observed that the physiological drive for maturity and spawning migration appears to stem from the rise in temperature and salinity during the season. In Kerala, according to Raman (1967) the breeding period is from August to December with a peak in October-November. In both places the breeding period follows the predominant monsoon season of the area.

Population and fishery

Sex ratio:- In general in the Pamba river system and adjoining backwaters when the fishery commences in May-June at the various centres males far outnumber the females (table V). From August onwards females predominate and continues so up to October. In November males once again become more numerous.

TABLE V

Sex ratio of the catches from Kumarakom and Ramankari during 1960-63 (Raman 1967)

Months	1960 Male %	1961 Male %	1962 Male %	1963 Male %
Kumarakom				
June	69.2	80.0	..	..
July	69.9	68.0	62.5	53.3
August	48.4	46.1	40.7	49.5
September	..	29.5	66.7	29.7
October	16.7	21.6	28.6	..
November	53.3	..	50.0	..
December	44.9	..	..	..
Ramankari				
March	..	95.0	..	..
April	..	89.4	..	67.4
May	97.2	85.9	..	..
June	67.8	90.0	73.1	60.9
July	65.8	51.4	..	41.8
August	50.6	35.6	..	23.6
September	54.3	31.6	..	41.7
October	52.9	29.8	48.5	..
November	..	..	..	70.0

In the Hooghly estuarine system sex ratios of the species in percentages calculated for different ages of the population and tested on "null hypothesis" show that only 0-year group conforms to the equiproportional ratio while higher age groups are significantly different, even at one percent level. The percentage of males are seen to be constantly on the decline as age advances while those of the females are on the increase, possibly denoting a higher rate of mortality in males than in females. At Nabadwip, an important landing centre situated at the entrance of the freshwater zone of the Hooghly estuary, differential proportion of sexes during different periods of the year are noticed. Males are predominant in February and again in September while females are dominant in February and again from September to January. This probably shows that there are discreet shoaling habits of sexes for purposes of spawning. During the peak of the spawning season March to May almost only berried females are found. Percentages of immature males and females at the same centre also show a similar trend of differential migration, males appearing in the fishery early in January while females enter later during March-April months.

Instances of sex reversal has been reported by Rao (1967), in laboratory rearing experiments. Live berried females collected from the vicinity of Barrackpore during June 1965, after hatching out the larvae, on further rearing in the tanks were found to change into individuals showing male secondary sexual characters by September after passing through one to two post-spawning moults.

Age composition:- In the Pamba river system in Kerala the 0-year class approaching one year age is present in the catch as a mode at 141-160 mm in March, 161-180 mm in April and 181-200 mm in June at Ramankari. This shifts to 261-280 mm by October and even 281-300 mm in November in some years. On the assumption that they represent the early brood of last season it is apparent that they grow to about 200,220 mm in one year. The large ones are the products of the previous years breeding and hence more than one year old, while those forming the mode at 261-280 mm found in July-August have already entered the second year. A good number of males survive into the second year while in the case of females the second year group is missing.

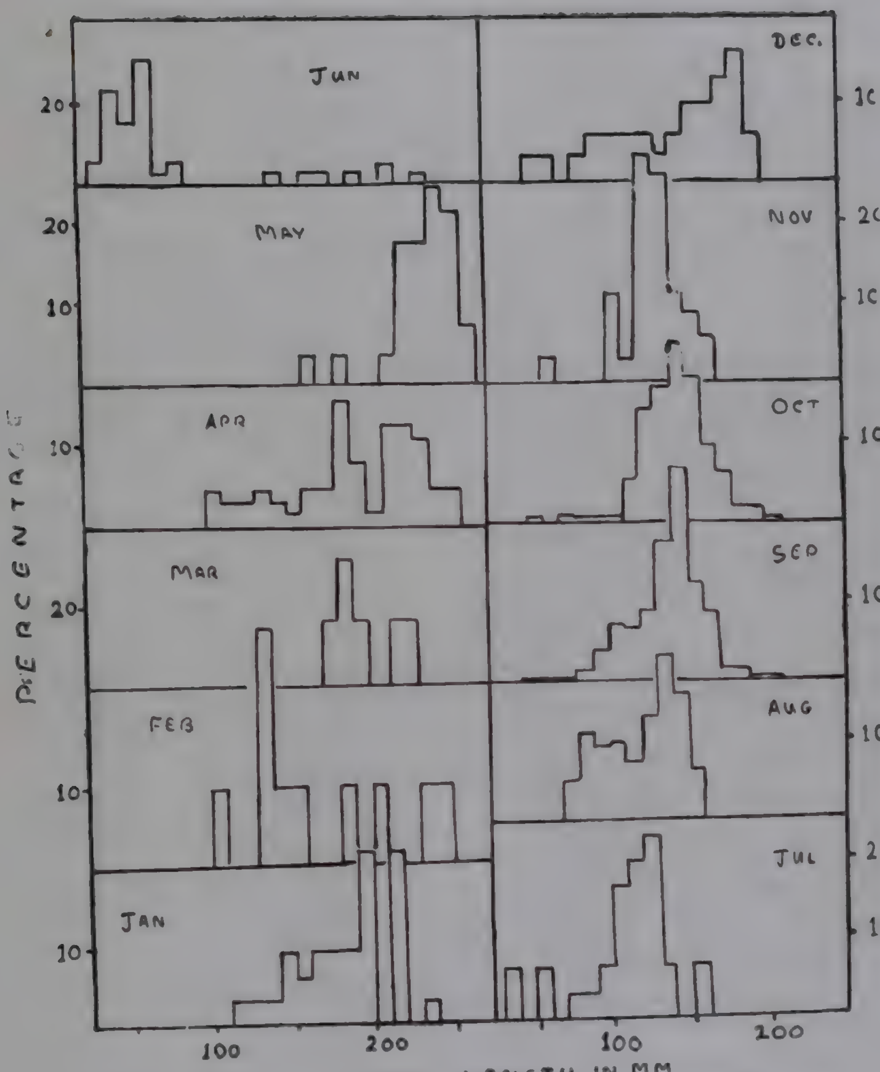

Fig 41. Length frequency distribution of females during different months-data pooled for the years 1962 to 1965 (Rao, 1967)

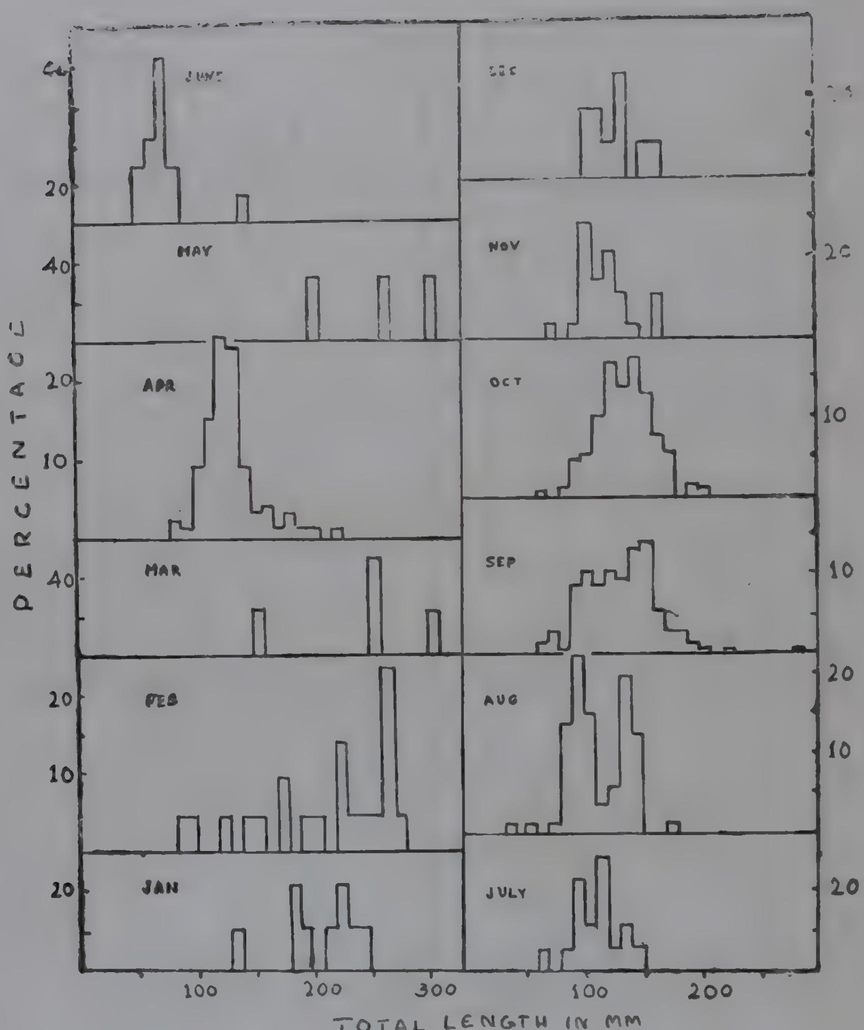

Fig. 42. Length frequency distribution of male during different months-data pooled for the years 1962 to 1965 (Rao, 1967)

By analysis of length frequency curves by the probability plot technique, Rao (1967) arrives at a different picture concerning age composition in the Hooghly estuarine system. He recognises 4 year classes in the fishery here, with lengths 113.67 mm, 142.0 mm, 226.0 mm and 261.0 mm in the case of males and 83.25 mm, 127.0 mm, 157.67 mm and 221.0 mm in females for the 4 years respectively. In the fresh water zone of the Hooghly river the maximum amount of fishery is constituted by I and II year groups followed by 0, III and other age groups. During the months January to April the fishery is constituted by all age groups except 0-year individuals, the dominant ages being II and III years. During May and June the fishery, though less, is mostly of III and IV years. Between the months June and December 0-year groups are available, the peak period being August to October. July to August months mostly comprise of I year age groups. During September to November the fishery is mainly of post-spawners consisting of II year and subsequent ages.

Size composition:- Monthly size frequency histograms of males and females in the catches from 3 centres in the Pamba river system and adjoining backwaters during the year 1961 (Raman 1967) and in the catches of Hooghly estuarine system for the years 1962 to 1965 (Rao 1967) are shown in figures 41 to 44.

The maximum length of the species according to Patwardhan (1937) is more than a foot (3 feet from tip of telson to tip of extended 2nd leg). In the studies of Hooghly estuary the maximum lengths observed are 310 mm total length (80.78 mm carapace length) for males and 267.0 mm total length (68.14 mm carapace length) for females. According to Rajyalakshmi (1961) the largest theoretical size (100) estimated to be attained by the species is 396 mm and the largest size recorded by her is 310 mm. Raman (1967) records a maximum size of 320 mm in the case of males.

The maximum size at maturity for females given by Rajyalakshmi (1961) is 136 mm, aged 2 years. According to Rao (1967) the mean sizes of maturity for females and males respectively as indicated by 50 percent levels are 155 mm and 175 mm.

Based on 873 observations of length range from 30 mm to 305 mm, Rao (op.cit.) found that the lengths and weights were related to each other linearly conforming to the formula:-

$$\text{Log } W = -5.52748 + 3.19346 \log L \quad \text{or}$$
$$W = 0.00007222 \times L^{3.19346}$$

Rajyalakshmi (1962) had earlier arrived at the formula

$$\log W = -5.5837 + 3.2276 \log L$$

The total length - carapace length relationship was worked out by Rao (1967) and the formula obtained by him were

$$\log C.L. = -0.92760 + 1.13787 \log T.L. \text{ and}$$
$$\log T.L. = +0.88675 + 0.83088 \log C.L.$$

Raman (1967) also found that these body measurements have a linear relationship. The formula given by him are:-

$$\left.\begin{aligned} C.L. &= 0.32281\ T.L. - 10.81851 \\ T.L. &= 3.06401\ C.L. - 35.08947 \end{aligned}\right\} \text{Males}$$

and

$$\left.\begin{aligned} C.L. &= 0.27892\ T.L. - 5.67957 \\ T.L. &= 3.58076\ C.L. - 20.53643 \end{aligned}\right\} \text{Females}$$

Abundance and density:- The estimated annual production figures from 1957 to 1962 (Table VI) from the Kerala backwaters given by Raman (1967) shows that the catches of the species remained more or less steady around 300 m. tons till 1961. Maximum of 429 m.tons was recorded in 1960 while 1962 shows the lowest.

TABLE VI

Estimated production of *M. rosenbergii* for the years 1957-62.

Year	1957	1958	1959	1960	1961	1962
Total production in m. tons	356	296	378	429	307	189

The monthly catches at two centres Ramankari and Kumarakom are also given by him.

The relative abundance of the species in the Hooghly estuary

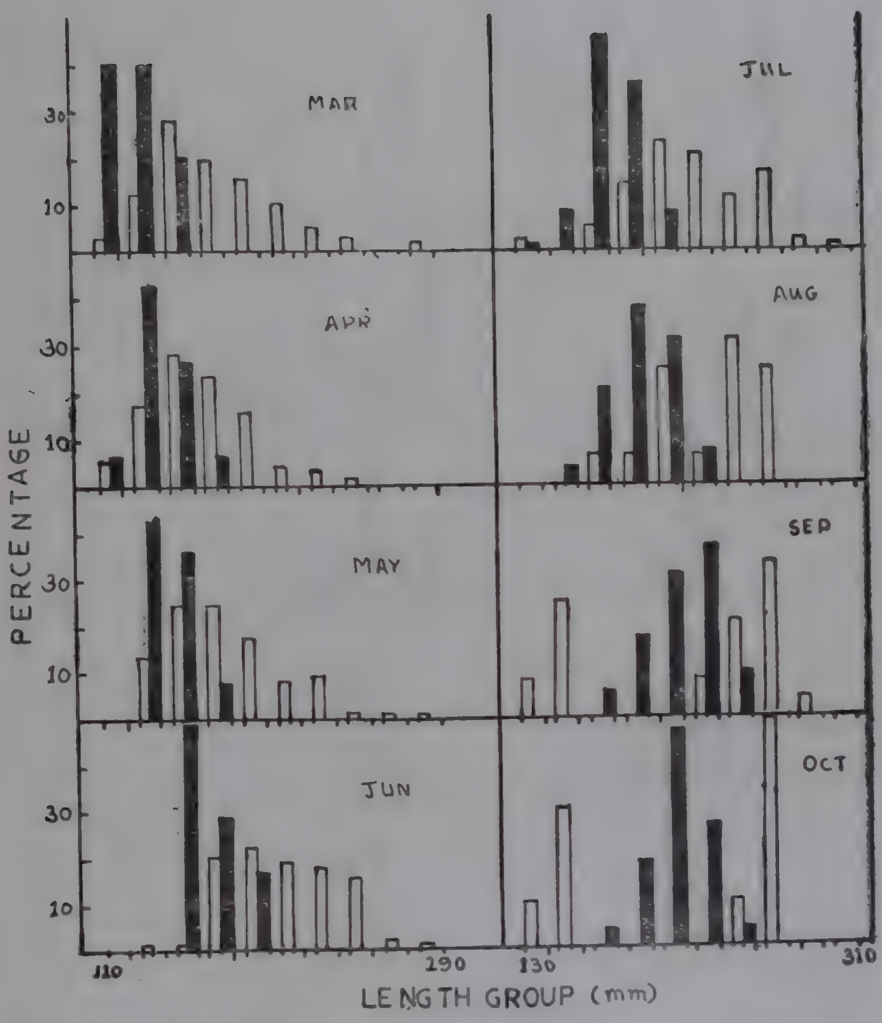

Fig. 43. Monthly frequency histograms of *M. rosenbergii* from Ramankari during 1961. Females shaded. (Raman, 1967)

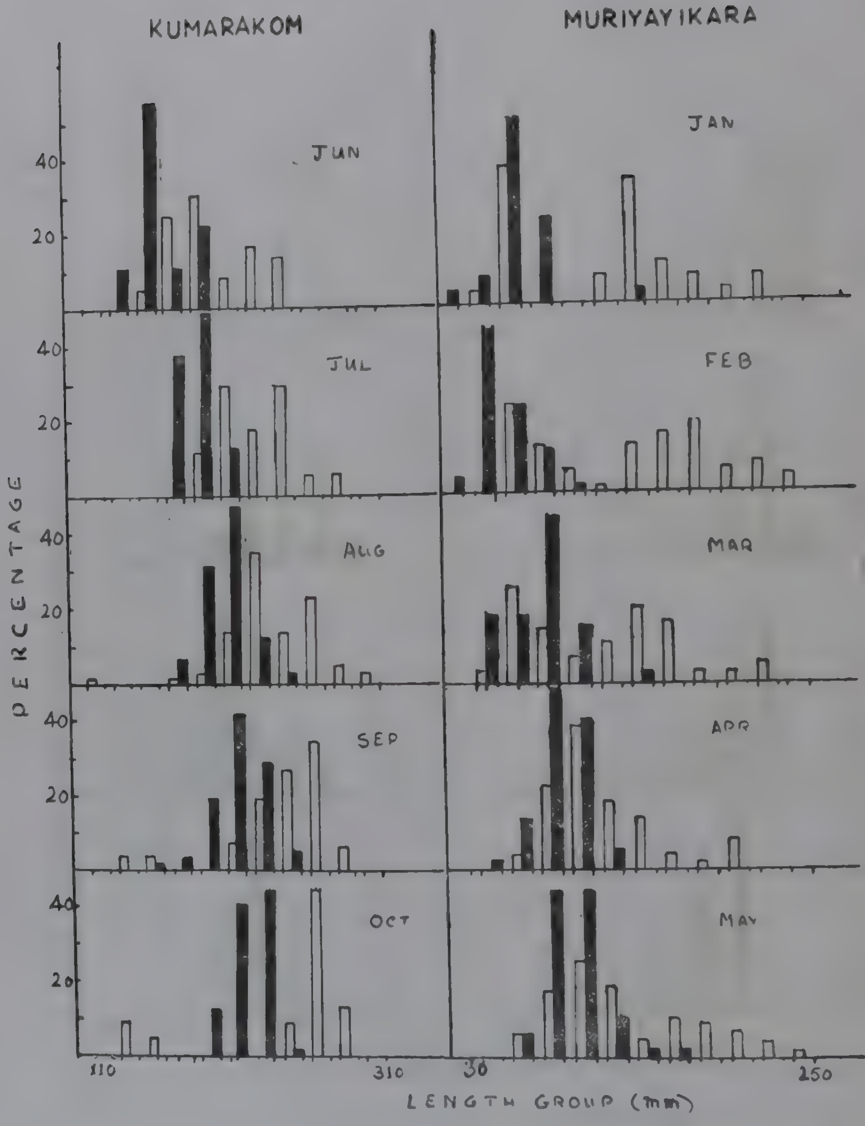

Fig.4 4 . Monthly frequency histograms of *M. rosenbergii* from Kumarakom and Muriyayikara during 1961. Females shaded. (Raman, 1967)

fishery is discussed by Rao (1969). The composition of species in the catches of the estuary in different years from 1962 to 1966 given by him are shown in table VII.

TABLE VII

Composition of M. rosenbergii in the catches of two zones of the Hooghly estuary during different seasons from 1962 to 1966

Zone	% of proportion of occurrence	1962-63 Landings in tonnes	%	1963-64 Landings tonnes	%	1964-65 Landings tonnes	%	1965-66 Landings tonnes	%	Mean of all Landings tonnes	%
Fresh water zone	91.16	1.072	3.81	5.093	2.2	1.006	0.63	1.098	0.56	2.068	1.35
Middle zone (Sal: 0.10-12.68°/..)	4.62	0.043	0.14	0.106	0.15	0.231	0.69	0.039	0.15	0.105	0.26
Roopnarayan river (Sal: 0.0-5.72°/..)	4.22	..	..	0.383	0.63	..	..	..	..	0.096	0.15

Natality and recruitment:- In the Pamba river system in Kerala from September onwards good numbers of the larvae of the species are seen in surface plankton hauls taken from places like Pallathuruthu and Kumarakom, the backwater centres, but are very rare in collections from places in the upper areas. In late October and November they are obtained from the Cochin backwaters also in large numbers. After they complete the larval life in the backwaters the juveniles go up the river by December or early January. In February also fresh recruits arrive at the upper reaches of the Pamba river. As reported by Raman (1964) during the summer months the juveniles are seen concentrating in the deeper zones of the river near Pulikizh so that the place can be considered as a nursery ground. They come down the river and get recruited into the backwaters with the onset of the monsoon.

In the Hooghly estuary recruitment of the juveniles and different age groups to the fresh water as well as gradiant zones of the river takes

place at different seasons. In the freshwater zone the 0-year groups get recruited in the period June to December with the peak period between August and October. 1st year groups are mostly recruited in July-August. During September to November the fishery is mainly of post-spawners consisting of II year and subsequent ages. In the gradiant zone females in berry and of advanced stages of maturity are recruited from February to July.

Mortality:- Rao (1967) found that when the ratios in percentages were plotted for each sex against the ages, the ratios in males have been on constant decline while those of females were on the increase. This according to him denoted a higher rate of mortality in males than in females.

Fishing gear:- In the Hooghly estuarine system, though the species is caught in every kind of net in stray cases, normally they are captured in traps (bithi and duarbithi), bush (kumor) and light fishing and cast nets, which are generally meant for prawns in the freshwater zone of the estuary. Operations involving hauling are done during the low tides because of the bottom-feeding habits of the species. Traps are located all along the river in the freshwater zone on the banks. These are kept in the highest high tide and the prawns are taken out during the low tides. In bush fishing twigs and branches of trees are planted on the banks of the river in a cluster, where water depths are not more than 2 fathoms, and the leaves are allowed to decay for a fortnight. Then, during the low tides Kumor jal, a drag net of 30 to 40 feet in length with 1/2" to 1" mesh size with earthern sinkers is encircled around the bush. While the branches are being taken out, the bottom of the net is gradually scooped centripetally and ultimately joined by two or three fishermen and finally the net hauled. The cast nets, khapla, are generally operated during the low tides in knee-deep waters by fishermen where the bottom is uneven and rough. In the gradiant zone of the Hooghly the species is generally caught in the bag nets, thor and been jals and cast nets. Purely prawn nets like 'morjals' and 'sitkijals' are also operated near the shore in some areas.

In the Pamba river system and adjoining backwaters, fishing for the species is generally carried out by individual fishermen using

mainly '<u>veechu vala</u>' (cast net) or '<u>ottal</u>' (a conical contrivance open at both ends, made of thin bamboo strips) with the help of a small dug-out canoe. Occasionally various types of drag nets such as <u>vadi vala</u>, <u>koru vala</u> and <u>peru vala</u> also catch small numbers of this prawn along with other fishes. <u>Vatta vala</u> (a pouch net) and <u>anta vala</u> (drag net) are used to catch these prawns from among submerged vegetation. While fishing with cast nets, baits are dropped in water and their position marked by poles. After allowing some time for the prawns to approach the bait the cast net is operated over the baits. This type of fishing is usually carried out at night in depths varying from 3 to 6 metres. <u>Ottal</u> is used in shallow areas 1-2 metres deep. Same type of baits attached to small floats are dropped in the fields and when the float is found moving the ottal is plunged above it and the prawns collected with bear hands. Vadi vala is used for fishing in the shallow parts of the river and backwaters. In some places in the northern parts of the Vembanad lake between Vaikom and Cochin the prawn is also caught with hook and line.

<u>Fishing boats</u>:- Most of the fishing operations for the species being in shallow waters and near the banks, boats are not generally employed in the fishery. However, in the operation of the gears like veechu vala small dug-out canoes operated by single persons are made use of.

<u>Fishing areas</u>:- <u>M. rosenbergii</u> supports a lucrative fishery in the Pamba river system and the adjoining backwaters of central Kerala. It is mostly caught from the southern regions of the Vembanad lake as well as the Kayamkulam lake and the important rivers opening into them, namely, Moovattupuzha, Meenachil, Pamba and Achankoil rivers.

In the Hooghly estuarine system the species forms considerable fishery in the freshwater zones of the Hooghly river, the Roopnarayan and Ichamati rivers. In the gradiant zones of these rivers also it forms a fishery to a lesser extent. The species also contributes to the prawn fishery in <u>bheris</u> in Bengal.

<u>Fishing season</u>:- In Kerala backwaters the fishery commences in May-June, reaches the peak in July-August and September months and then decline, lasting usually upto November.

In the freshwater zone of the Hooghly river, although the fishery is active throughout the year, the main season lasts from May-June to December, with the peak period August to November. In the gradiant zone of the same, the fishery mostly confined to the Ulubaria-Fuleswar region lasts from February to July, mostly contributed by females in berry and advanced maturity stages. According to Rao (1969) also the peak season for the species here is during the monsoon.

Fishing operation and results:- Catch-effort data collected from the two observation centres given by Raman (1967) are reproduced in table VIII. The unit of fishing effort (unit per day) is computed on the basis of one fisherman working with one craft and gear.

TABLE VIII

Total effort, total catch and catch per unit of effort at two observation centres during 1958 to 1963

	1958	1959	1960	1961	1962	1963
I. Ramankari						
Fishing effort (Unit/day)	2081	3622	2807	1428	415	1427
Total catch (kg)	2987.3	5584.4	5826.6	2621.1	488.4	2778.4
Catch per unit of effort (kg)	1.436	1.542	2.076	1.835	1.177	1.947
II. Kumarakom						
Fishing effort (Unit/day)	..	..	..	1869	715	1045
Total catch (kg)	..	..	..	4944.1	1064.2	1596.1
Catch per unit of effort (kg)	..	..	..	2.644	1.488	1.527

Of all these years at Ramankari 1960 seems to be the most productive as shown in the table and 1962 the least productive. In 1959 both effort and catch rate showed increase from the previous year. In ~~1960~~ 1961 the effort is less. The minimum of effort is recorded in 1962 which was a poor season. At Kumarakom also 1962 was a very poor season with the lowest effort and catch rate among the three years. Here also the catch improved slightly in 1963.

Prawn culture:- Being a fast growing species M. rosenbergii is an ideal prawn for culture. The possibilities of culturing this prawn has been suggested by several authors. Possibilities of establishing artificial hatcheries also were suggested by several including Naidu (1939)

and Mary John (1957). Raman (1964) reported about a nursery ground of the species near Pulikizh from where juveniles could be collected for purposes of culture. The best time for collection of juveniles from this area according to him is January and February months. He also suggested the possibility of the existence of similar nursery areas with similar ecological conditions in the river systems associated with Vembanad lake.

In connection with culture of the species and stocking young ones in the Hooghly estuarine system, Rao (1967) reported about several centres from where postlarvae could be collected. The postlarvae and youngest juveniles are found in shallow canals of rivers, of about 1 metre deep and are fished by local fishermen with fine meshed cloth and small bag nets 1 metre diameter at the mouth and 2 to 3 metres length, the mouth end being exposed above the water level during operation in very slow currents of water.

Ling's studies in Malaya were aimed at making rearing of the species a profitable proposition. He (1962 and 1963) after successfully breeding and rearing the larvae in laboratory tanks describes the techniques for culturing these prawns. Details concerning facilities and material required, larval food and techniques and procedure of rearing are given by him.

Protection and Management:- In the Kerala backwaters apprehension concerning depletionary tendencies in the production of this giant prawn has been prevalent for some time. Since the species is subjected to fishery at different stages of its life, there is likelihood of the stock being depleted at some time or other. Mary John (1957) pointed out this possibility and emphasised the need for the protection of the breeders. Studying the fishery up to 1963 Raman (1967) was of opinion that no alarming tendency of depletion was evident till that time. A self-imposed close season during October-November 1963 by the freezing industry was welcome trial. But it was discontinued in later years. However, Raman (op.cit.) observed that the indiscriminate destruction of fry by fishing with small mesh nets like peru vala and koru vala in the upper reaches of the rivers during the summer months might adversely affect the prawn stocks in the long run. He also feared that the use of copper

sulphate for catching the riverine fishes by poisoning in the same areas which are the nursery grounds of the prawn was killing good numbers of the juveniles of the prawn. So he suggested that a closed season tried along with some measures for protecting the nursery areas during summer months might be useful in getting a sustained yield from the fishery. So far no such measures have been taken in the case of this prawn fishery. It is reported that the fishery for this giant prawn in the Pamba river system and Vembanad lake has been a complete failure during 1968 season. It remains to be seen whether there would be survival of the fishery in the 1969 season.

2. MACROBRACHIUM MALCOLMSONII (H. MILNE EDWARDS)

Common name

It is one of the "chingris" on the east coast of India.

Diagnostic features (Fig.45).

Rostrum projects beyond the antennular peduncle for about 1/5 of its length. Dorsally the proximal portion is highly convex and the distal part more or less straight and much shorter, carrying one or two teeth near the apex. The proximal portion is relatively deep and the distal portion much narrower. The tooth formula is 9 to 11 + 1 or 2 (most commonly 10 to 11 + 1) and ventrally 5 to 7 (most commonly 6). As in M. rosenbergii the first 3 upper teeth or rarely the first 2 are on the carapace.

The large chelipeds are subequal in length and resemble those of M. rosenbergii, but the spinules are not so strongly developed, and are more closely set; the movable finger is somewhat less pubescent; a groove traverses both the upper and lower surfaces of the palm and carpus, recalling the longitudinal lines present in M. rosenbergii. The chelipeds are less than double the body length. The ischium and fingers are comparitively shorter than in adult males of M. rosenbergii. In females these chelipeds are scabrous and two-thirds the length of the body. The palm

is slightly compressed dorsoventrally and of uniform width; it is as wide as or slightly wider than the distal end of the carpus. The mobile finger is not pubescent. The grooves on the carpus and palm, characteristic of males are absent in the female.

In the male the anterior surface of the carpace, the posteroventral regions of the first five abdominal epimera, the anterior region of the second abdominal epimeron and sometimes of the first, fifth and sixth abdominal terga and the upper surface of the telson are scabrous. The thoracic legs with the exception of their dactyli are provided with very numerous closely set spinules. In the female the body is smooth and exhibits none of the roughness characteristic of males.

The telson tip as in M. rosenbergii is acutely pointed. The inner subterminal spinule on each side projects backwards beyond the outer one, but does not nearly reach the telson tip.

In specimens under 110 mm in total length the rostrum may be slightly upturned distally and may extend a little beyond the distal margin of the antennal squame.

Distribution

General distribution:- The species inhabits fresh and salt waters. It is known only from the eastern parts of India and Burma. According to the land and water areas code given by Holthuis and Rosa (1965) the distribution of this species in land areas is in 421 (w), 423 and 431. In water areas it is distributed in the region ISW.

In India the species is common in the Chilka lake and peninsular rivers that drain into the Bay of Bengal and Deltaic Bengal. The fresh water prawn fishery of the river Godavari is constituted mainly by this species.

Differential distribution:- As the species show some migration to brackish waters for breeding in the Hooghly estuarine system, a certain amount of differential distribution of stages in the life history is noticed there. But in Godavari river no such differential distribution is noticed by Ibrahim (1962).

Life history

Eggs and larvae:- The early embryonic development from fertilized egg to gastrulation of the species is described by Ibrahim (1962) (Fig.46 a-f). The eggs immediately after extrusion measure on an average 0.52 mm in length and are either spherical or elliptical in shape with a thin egg membrane provided with a coating of transparent adhesive secretion. The stellate island of protoplasm containing the nucleus is discerned in the centre of the egg. Commencement of cleavage is rather slow. Within 4.45 hours after fertilization the nucleus divides into two. The second nuclear division followed by the first appearance of cleavage furrows takes place by 9.45 hours. 8 blastmere stage is reached 2 hours later. Up to this stage the nucleus of each blastomere is distinctly seen. After 12.45 hours 16-celled stage is attained. Gastrulation commences 32.15 hours after fertilization. In a region of the egg which is destined to develope as the ventral aspect of the embryo, certain cells get detached from the egg membrane resulting in the formation of some space between the egg membrane and yolk cells. Consequently the blastoderm develops as a thin plate between the egg membrane and the yolk cells. Just before hatching the egg measures 0.629 mm. Hatching takes place on the 12th day after fertilization, much earlier than in M. rosenbergii. An account of the later embryonic development, hatching and the first stage larva is given by Rajyalakshmi (1960). The figure of the larva given by her is shown in fig.46.

Nutrition and growth:- As in the case of other prawns this species is also found to be omnivorous. The percentages of various items of food in the stomach contents given by Ibrahim (1962), based on analysis of stomachs of 407 specimens are shwon in table ~~XIX~~ IX.

Generally mud, sand grains and debris constituted the major part of the stomach contents, forming 65.7% and 35.9% in adults and juveniles respectively. Apart from this the adults and juveniles show differences in the food items as can be seen in the table. In the stomachs of juveniles the percentage of diatoms are much more than in adults suggesting that juveniles at times resort to surface feeding also.

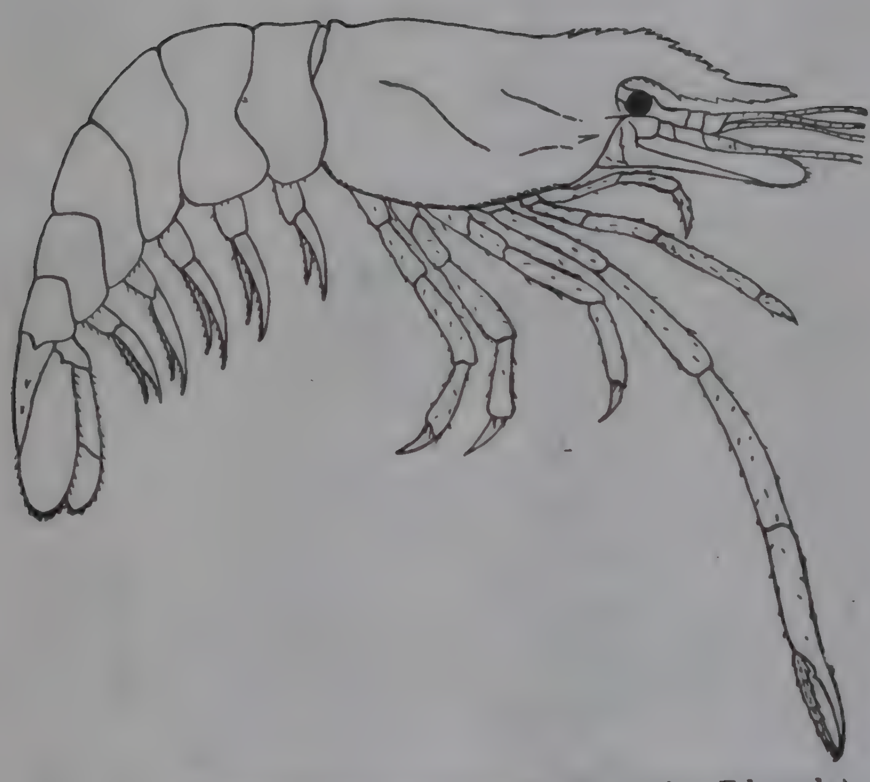

Fig. 45. *Macrobrachium malcolmsonii* (H. Milne Edwards)

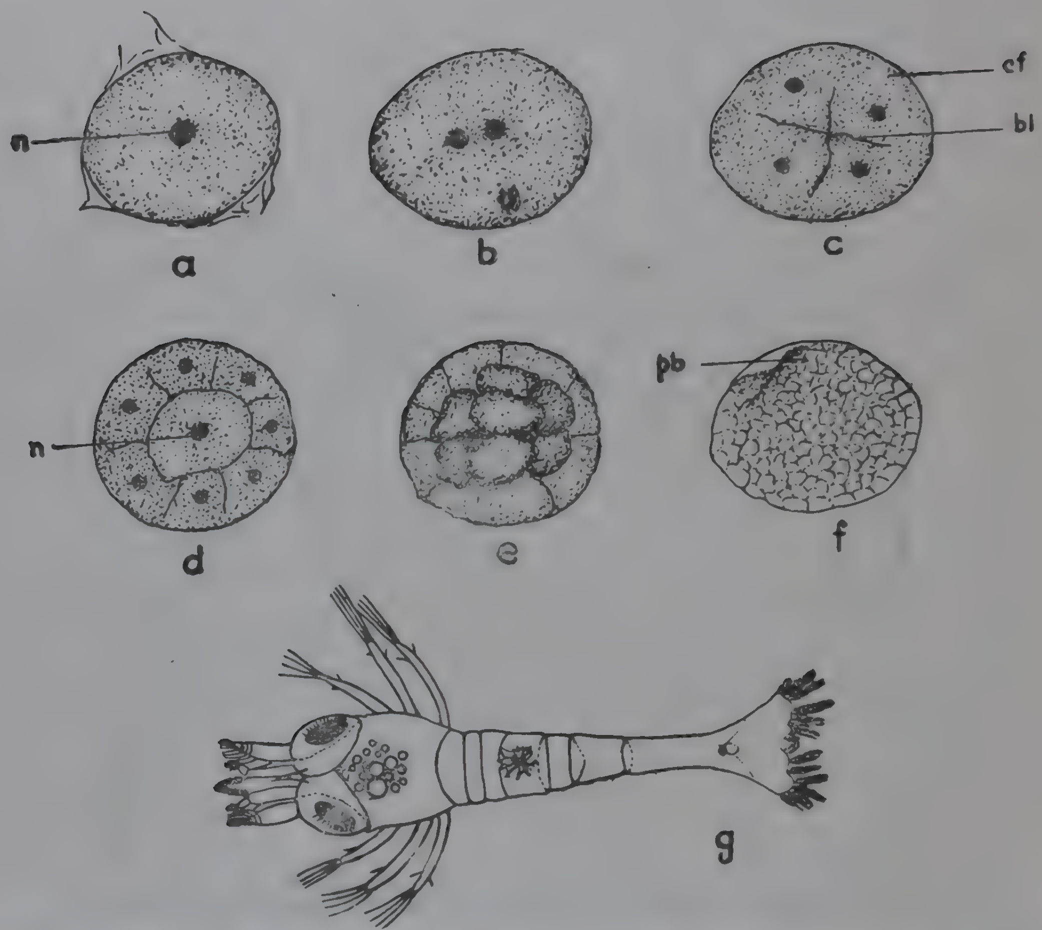

Fig. 46. Nuclear divisions, cleaveges and gastrulation in egg of *M. malcolmsonii* (a to f). bl-Blastomere, cf-cleavage furrow, n-nucleus. pb-problastopore (After Ibrahim, 1962) g-First stage larva of *M. malcolmsonii* (After Rajyalakshmi, 1960)

TABLE IX

Percentage of food items in the gut of juveniles and adults of M. malcolmsonii

Gut contents	Juveniles (T.L. 19.0-35.0 mm)	adults (above 35.0 mm)
Debris	19.8	41.7
Mud and sand grains	16.1	24.0
Diptera larvae (Chironomid)	4.3	5.1
Insect parts	3.6	5.4
Cladocera	0.2	0.6
Copepoda	0.8	0.3
Crustacean appendages & fragments	4.1	5.8
Diatoms (Stauroneis, Navicula, Frustulia)	33.7	2.2
Desmids (Cosmarium sp.)	2.4	0.2
Filamentous algae (Spirogyra)	3.0	2.9
Macrovegetation (plant parts; pieces of leaves etc.)	6.6	7.6
Fish scales	2.8	1.2
Miscellaneous	2.6	3.0

In the matter of growth, Ibrahim (1962) studying the prawns in the Godavari river and Rajyalakshmi (1964) from Hooghly estuary arrive at different conclusions, using the same method of probability plot. Their results are given in tables X and XI. While in the Godavari the males of the species have been estimated to grow 80.0, 63.5 and 50.0 mm during the first, second and third years of life and females 74.5, 39.0 and 35.0 mm in these years respectively, in the Hooghly estuary the postulated growths are much slower. There the males register a growth of 58.0, 32.5 and 28.0 mm in the first, second and third years respectively and females 56.0 and 37.5 mm in the first and second years. The disparity observed in growth rates of the species in the two estuaries could probably be attributed either to environmental factors or to differences in population abundance, if not to inaccuracies in interpretation.

TABLE X

Results of analysis of percentage length frequency distribution of M. malcolmsonii by probability plot method for 1960-62 (Ibrahim 1962)

Year	Males: Age in years	Males: Modal length (mm)	Males: Standard deviation (mm)	Males: Increment in length (mm)	Females: Age in years	Females: Modal length (mm)	Females: Standard deviation (mm)	Females: Increment in length (mm)
1960-61	0	44.0	± 5.2419		0	44.5	± 6.85	
	I	62.0	±14.3010		I	65.0	± 8.33	
		98.0	±11.6935			84.5	± 7.66	
				63.5				39.5
	II	129.5	±10.8870		II	105.5	± 6.82	
		158.0	±12.5000			122.5	± 6.04	
				50.0				35.0
	III	183.0	±10.2150		III	139.5	± 6.04	
		204.0	± 5.7451			158.5	± 8.87	
1961-62	0	43.0	± 5.1075		0	42.0	± 4.9731	
	I	61.0	±11.0215		I	62.0	± 7.3924	
		89.0	± 8.3876			79.0	± 8.6021	
				50.0				40.5
	II	112.0	± 7.7957		II	101.0	± 6.6982	
		137.0	± 8.1187			121.5	± 6.8548	
				50.0				24.5
	III	162.0	± 9.6774		III	135.5	±10.6182	
		187.0	±11.9623			..	..	

TABLE XI

Results of analysis of size frequency distributions by the use of probability paper in M. malcolmsonii for the years 1959 through 1961 (Rajyalakshmi 1964)

Age in years		Mean length (mm)	Standard deviation (mm)	Increment in length (mm)
Male	0	40.0	± 4.301	18.0
	I	58.0	± 9.543	32.5
	II	90.5	± 8.333	28.0
	III	118.5	±11.156	
Female	0	36.5	± 5.242	19.5
	I	56.0	±10.887	37.5
	II	93.5	± 9.409	

Ibrahim (1962) found several of this prawn in the Godavari river parasitised by the bopyrid Palaegyge alcocki. Parasitisation was observed to cause retardation of overall growth as well as sexual development. In the case of infected prawns growth increments of only 27.0 mm and 26.5 mm during 1960 and 1961 respectively (Table XII) are evident between first and second year groups. In comparison with normal growth rate this is much slow.

TABLE XII

Analysis of length frequency in parasitised prawns by the probability plot method (Ibrahim 1962)

Year	Age in years	Modal length (mm)	Standard deviation (mm)	Increment in length (mm)
1960	0	43.5	± 3.763	..
	I	54.0	± 5.376	..
		72.0	± 8.199	
	II	84.0	± 6.182	27.0
		96.0	± 3.763	
	III	..	..	..
1961	0	..	..	..
	I	53.5	± 4.301	..
		64.0	± 5.846	..
				26.5
	II	81.0	± 4.838	..
		89.5	± 5.511	..
	III	..	..	..

The absence of any parasitised prawn above 115.0 mm length possibly indicates that only those that are not attacked by the parasite grow beyond that size. Again parasitised prawns were never observed to carry eggs and their gonads were in a degenerate condition, indicating a retarded sexual development due to parasitisation.

Behaviour and movements:- In this prawn a simple behaviour of movement to shallow waters at dusk and during night is noticed in river Godavari and also in Chilka lake. Extreme limits of salinity tolerence for the species in the Hooghly estuary according to Rao (1969) is 0.0 to 9.0 °/₀₀. In the Godavari river in this species there appear to be no breeding migration towards the lower areas. In the monsoon season when

the whole stretch of the river up to the mouth show freshwater conditions intensive breeding takes place throughout the areas. However, an interesting upstream movement of juveniles is noticed here. Juveniles are found to move upstream over the first anicut of the river at Dowleishwaram. The movement of these young prawns from the lower region of the anicut to the upper region was practically negligible during daytime but very intensive in the night. They were observed to move along the sloping cement pavement of the anicut alongside the descending water. It was observed that during January and February when the iron sills of the anicut were raised the young prawns moved vertically up these sills and the walls. This upstream movement recorded in August continued till February when the flow of water over the anicut ceased and was resumed in June when the overflow over the anicut commenced again. During December-January this movement becomes so intensive that the local fishermen collect large quantities of the juveniles which are sold fresh or dried. Length frequency analysis of samples from these upward moving juveniles show their sized ranging from 13.0 mm to 60.0 mm with the major portion ranging in size from 21.0 to 36.0 mm (mode 30.0 mm).

Reproduction:- In the studies in the fishery of Godavari river, it is found that the gonads begin to ripen from April and more frequently from June onwards. Percentage of mature females increase from 11.3 in May to 37.8 and 38.7 in August and September respectively. The average weight of ovary per gram body weight of prawn ranged from 0.036 g (for size group 57.0 - 61.0 mm) to 0.067 g (for size group 77.0 -81.0 mm). The weight of ovary was comparatively less among the 0 and III year classes but higher among I and II year groups. The size at first maturity was found to be 41.0 mm, aged 1 year.

The breeding period of the species in Godavari river extends nearly to 8 months from April to November with at least two peaks, once in June and again in August-October (Table XIII).

Intensive breeding commences immediately after the heavy rains. There are evidences to show that individuals beginning to breed for the first time become berried first. During the breeding season the one-year class constituted the predominant group in the catches.

TABLE XIII

Percentage of berried females of M. malcolmsonii in the commercial catches during 1960 and 1961

Month	1960		1961	
	% of berried females in total	% of berried individuals among females	% of berried females in total	% of berried individuals among females
April	..	..	0.83	..
May	0.75	..	8.38	11.33
June	22.41	28.53	23.93	29.58
July	9.39	14.35	15.04	21.80
August	7.25	29.26	18.79	37.85
September	15.49	24.62	27.11	38.78
October	17.05	37.85	9.70	20.20
November	0.24	..	0.70	01.70

The spawning period of the species in Hooghly river is, however, shorter during the months May to August (Rajyalakshmi 1964). According to Patwardhan (1937) the breeding season is still shorter, during May, June and July.

Fecundity studies on Godavari prawns indicate that the number of eggs in the berry ranged from 3,465 to 63,080 in specimens ranging from 54.0 mm to 164.0 mm respectively in size.

Hatchlings of 2.0 to 3.0 mm size range are found in plankton tows made at Rajamundry.

Population and fishery

Sex ratio:- Identification of sex is mainly based on the secondary sex characters. The appendix masculina being clearly visible at advanced stages, sex differentiation is possible only in specimens of 30.0 mm and above. In the Godavari river catches among the size groups 37.0 to 52.0 mm the proportion of males was considerably more than that of females and in sizes ranging between 57.0 to 77.0 mm (sizes breeding for the first time) females dominated. After this stage, however, males again predominate in

the catches up to 237.0 mm. Females were recorded only up to 197.0 mm and beyond this they were absent in commercial catches. X^2 test on sex ratio indicated that there are highly significant variations in sex ratio among different length groups. Larger numbers of males of larger sizes were observed by Rajyalakshmi (1964) and Bhimachar (1965) also.

Monthly analysis of sex ratio changes indicated that in the months May-June and September only females dominated while in all the other months males were predominant in the Godavari fishery. On pooling the sex ratios showed marked fluctuations during different seasons, more of females in the monsoon (June to September) and summer (March to May) and more of males in winter (October to February).

Age composition:- Observations on the fishery of this prawn in Godavari river during 1960 and 1961 indicated that among males the 0-year class contributed 13.0%, 1-year class 69.4%, 2-year class 16.3%, and 3-year class 1.2%. Among females 0-year class formed 9.1%, 1-year class 75.3%, 2-year class 14.1% and 3-year class 1.4%. Thus the bulk of the commercial catch among both the sexes was constituted by 1-year and 2-year groups.

In Hooghly the fishery is constituted by 0, I, II and III year classes in males and only 0, I, and II year class in the case of females.

Size composition:- In Godavari catches the size of males ranged from 30.0 mm to 237.0 mm while females ranged in size from 30.0 mm to 197.0 mm. The sizes of the different age groups are given in table X.

In the Hooghly river the smallest sized individuals (25.0 mm modal value) appear in commercial catches by November-December. For sizes of the different age groups constituting the fishery see Table XI. Modal lengths of the species in the fishery in different months are given by Rajyalakshmi (1964).

Minimum size at first maturity in female is 41.0 mm according to Ibrahim (1962). But Rajyalakshmi (1964) records a much higher size of 79.0 mm.

Henderson and Mathai (1910) records maximum sizes of 230 mm in males and 133 mm in females. Patwardhan (1937) mentions a maximum length of 15 inches (380 mm) from telson tip to the tip of the long legs. Ibrahim (1962) got specimens up to 237.0 mm and 197.0 mm in males and females respectively from Godavari. Rajyalakshmi (1964) estimated the asymptotic length in M. malcolmsonii as $L\infty$ = 246 mm and the maximum size of the species recorded by her in Hooghly river was 135 mm only.

Based on 1502 observations on length and weight Ibrahim (1962) observed that the increase in weight in the species was slightly higher than the cube of its length, conforming to the formula

$$W = 0.000001815485\ L^{3.38788} \quad \text{Males}$$

$$W = 0.000002728978\ L^{3.82041} \quad \text{Females}$$

Abundance and density:- The total annual prawn landings at Rajahmundry for the year 1959 to 1961 from a stretch of about 16-24 km given by Ibrahim (1962) are given in Table XIV.

TABLE XIV

Total landings of prawns at Rajahmundry for three years 1959-61.

Year	Landings in tonnes	Percentage in total fish landings	Value in rupees
1959	20.36*	14.32	43,650
1960	36.66	14.49	78,410
1961	35.76	19.53	76,670

*Data for only 10 months

Over 16.0% of the total fishery of the river Godavari is contributed by M. malcolmsonii. The relative abundance of the species in the Hooghly estuarine fishery was discussed by Rao (1969). The composition of the species in the total catches of Hooghly in different years (Table XV) are given by him.

TABLE XV

Composition of *M. malcolmsonii* in the catches of two zones of the Hooghly estuary during 1962-66

Zone	% of proportion of occurrence	1962-63 Landings in tonnes	%	1963-64 Landings in tonnes	%	1964-65 Landings in tonnes	%	1965-66 Landings in tonnes	%	Mean of all Landings in tonnes	%
Fresh water zone	82.27	0.408	1.45	9.306	4.02	2.411	1.51	4.892	2.50	4.254	2.77
Middle zone (Sal:0.10-12.68°/oo)	1.43	..	..	..	..	0.103	0.31	0.186	0.72	0.072	0.18
Roopnarayan river (Sal: up to 5.72°/oo)	14.30	..	..	0.517	0.85	0.336	0.68	2.034	2.84	0.722	1.14

Natality and recruitment:- In Hooghly the species breeds during the months May to August and the smallest sized individuals (with mean modal length 25.0 mm) get recruited in the commercial fishery by November-December, approximately 5-6 months later.

The heavy commercial fishery for this prawn in the Godavari river stretch between Dowleishwaram and Dummugudem, especially near Rajahmundry is substantially contributed by heavy recruitment of juveniles. Breeding taking place throughout the course of the river, the hatchlings that are washed down by the flood currents as well as those of the local breeders in the lower reaches of the river make a concerted slow migratory movement upstream as the salinity at the lower areas increases and these juveniles are recruited in the commercial fishery later in Rajahmundry area. The maximum recruitment and thereby maximum exploitation of the higher size groups occur in the summer months from March to June.

Fishing gear:- In Godavari river major landings of the species along with other prawns are by cast nets. The meshes of the net range from 7.0 to 26.0 mm. Drag nets with mesh range 7.0 to 20.0 mm are also used occasionally. Fishing by baiting with a mixture of rice, rice bran and oil cake is a common practice. Though prawn fishing is carried out both in day time and night large quantities of prawn are caught in the nights from the shallow regions of the river near the banks as well as around the exposed sand heaps in midstream.

In Hooghly estuary the prawn is caught along with others in traps (bithi and dwarbithi), bush (kumor) and light fishing and cast nets. Bag nets like thor and been jals and shore seines are also operated.

Fishing boats:- Most of the fishery for these prawns being done from shore and banks of the river, boats are not much employed in the fishery. However, in some operations small dug-out canoes are used.

Fishing areas:- In the Godavari river exploitation of this prawn extends up to about 800 km upstream of Rajahmundry, but is mainly confined to 1) Rajahmundry (Andhra Pradesh) at a distance of 80 km from sea, 2) Sironcha, 450 km from sea and 3) Nander, 800 km from sea (the latter two in Maharashtra) in a discontinuous manner.

In Hooghly the fishery is mostly confined to the fresh water and gradiant zones of the river.

Fishing season:- The fishery for prawns mostly contributed by this species at Rajahmundry has a peak season in the summer months from March to June. During the period July to December the catches are generally low. However, the fishery improves by February onwards. In the Hooghly estuary, in the upper zone the peak season is December to February (Rao 1969). There is another peak during monsoon also. In the middle zone and in Roopnarayan river the peak is during monsoon.

Fishing operation and results:- Details regarding the cast net fishery for this prawn at Rajahmundry area are given by Ibrahim (1962). During the months February to June about 38-90 fishermen families at Rajahmundry subsist on this prawn fishing, catching about 1.49 to 3.08 kg of

prawns per day per indidual fisherman.

Prawn culture:- Culture of fresh water prawns in inland waters is not practised much in India at present. Since M. malcolmsonii is one of the species that grows to large size it is worthwhile attempting culturing it inland waters such as large reservoirs and tanks. Collecting large sized sexually mature males and females and getting them spawn in laboratory tanks was found to be not very difficult by Ibrahim (1962). He found several berried specimens with eggs in advanced stages of development collected from Godavari river and kept in aquaria as well as small temporary pits hatching out their eggs successfully. He also observed repeated spawning of a female in the laboratory conditions. From the point of view of seed production this is quite important. The production of hatchlings and prawn seed could be augmented by properly tapping the source of the upstream migrating juveniles over the first anicut of the river Godavari as a prawn seed collection centres

Protection and management:- The heavy commercial prawn fishery in the river Godavari in the area between the two anicuts Dowleishwaram and Dummugudem, and in particular in the areas near Rajahmundry is substantially contributed by the heavy recruitment of juveniles. This is mainly due to the successful negotiation of the anicut by the juveniles. In the absence of fish passes, strict enforcement of conservancy measures on all the adjoining sides of the anicut during night, prohibiting the destruction of this valuable prawn fishery potential, will help in the further improvement of this fishery of the river.

VIII PRAWN GROUNDS ON THE CONTINENTAL SHELF FISHED BY TRAWLERS

By

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PRAWN GROUNDS ON THE CONTINENTAL SHELF FISHED BY TRAWLERS

K. Virabhadra Rao & K. Dorairaj

In the last two decades, the operations of large, medium and small trawlers of the Central and State Government organisations, the Indo-Norwegian Project and the commercial concerns have revealed good prawn grounds on the continental shelf of the coasts of India. Although most of the operations were carried out with trawls suitable for netting miscellaneous varieties of fishes, prawn catches obtained incidentally have given a fairly reliable picture of the distribution of the prawn grounds. In the following account the regional abundance of prawns is given on the basis of trawling operations carried out on the east and west coasts of India. The results are dealt below under four different divisions viz., 1. North-Western Division (Kutch to Goa), 2. South-Western Division (Karwar to Cape Comorin), 3. South-Eastern Division (Cape Comorin to Krishnapatnam) and 4. North-Eastern Division (Masulipatnam to Diamond Harbour).

PRAWN LANDINGS IN THE NORTH-WESTERN DIVISION

This division includes areas on the continental shelf between latitudes 24°N to 15°N and longitudes 66° E to 74° E. Six regions are recognised viz., Kutch, Dwarka, Porbundar, Veraval, Cambay and Bombay (Rao *et al*, 1966). The bull-trawling operations of the New India Fisheries vessels (*Arnala cum Paj* and *Satpati cum Pilotan* 250 H.P. each) in this division from 1956 to '63 have furnished some information. In 1956 and 1963 there was no fishing by these vessels in some of the months. In the rest of the period, taking all regions into consideration, it is seen that the catch and the catch rates were the highest in 1962 and the lowest catch and the catch rate were in 1959 and 1958 respectively. Regarding the regional abundance, it is seen from Table I and Fig.47 that the catch and the catch rate for prawns were the highest from Cambay region, but the percentage proportion of prawns in the region ranked next to that of Bombay. The catch per hour returns have been observed to be in the decreasing order in the rest of the regions i.e. Bombay, Veraval, Porbundar,

Kutch and Dwarka. The maximum monthly catch per hour returns from each region has shown a north to southward increase from Kutch (18.23 kg/hr) to Bombay (200 kg/hr).

TABLE I

Prawn landings by the New India Fisheries Company's vessels for 1957-'62. (after Rao *et al*, 1966)

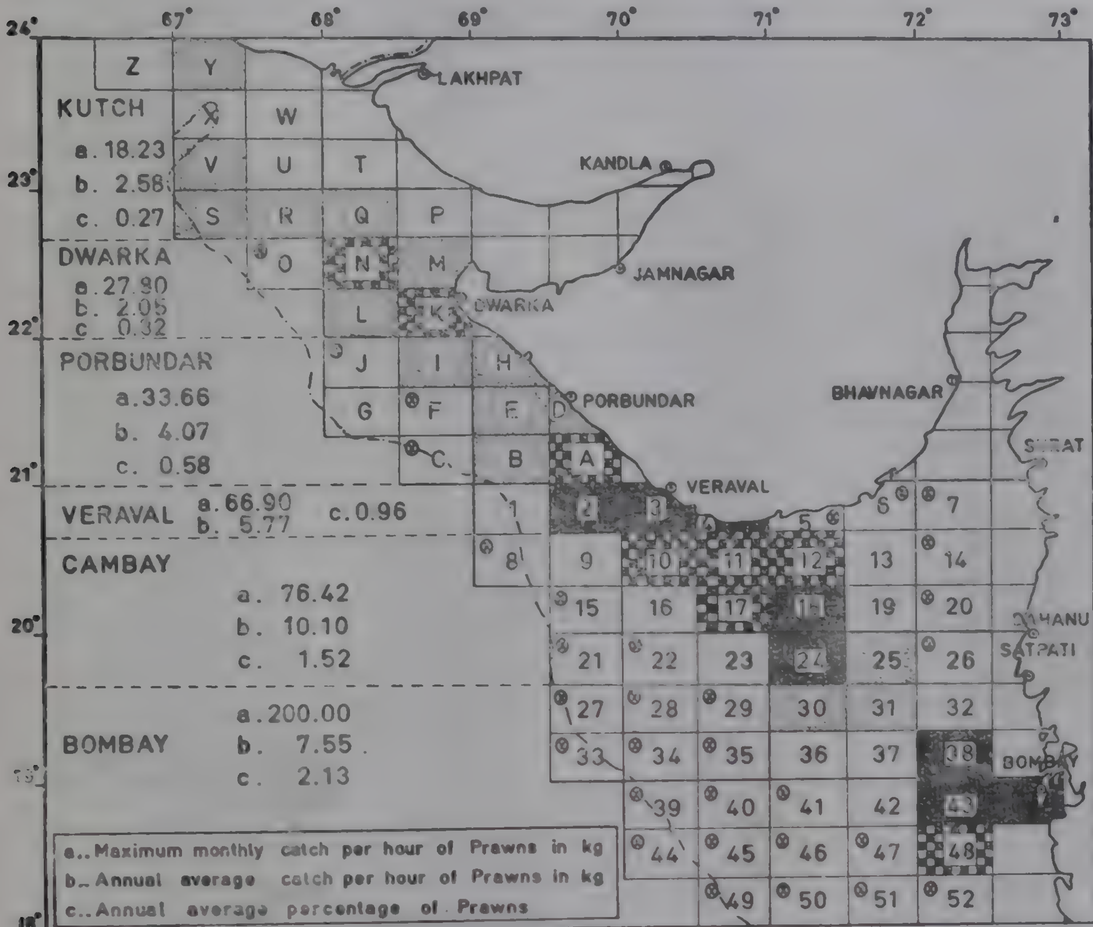
Region	Catch in kg	Region	Catch in kg
Kutch	3,707	Veraval	2,685
Dwarka	1,321	Cambay	11,078
Porbundar	4,351	Bombay	336

The productive areas shown in Fig.47 are based on the maximum monthly catch rates obtained. The areas are 600 square nautical miles each. Areas 2, 3, 4, 18, 24, 38, 43 and 43A are considered highly productive as they have given over 40 kg/hr; N, K, A, 10, 11, 12, 17 and 48 are moderately rich giving between 20.1 to 40 kg/hr; Y, V, S, R, Q, M, L, I, H, E, D, B, 25, 30 and 31 are fair giving between 10.1 to 20 kg/hr and the rest of the areas which have given less than 10 kg/hr are considered poor.

Kagwade (1967) working upon the data of New India Fisheries vessels for the eight year period has obtained very similar results.

The larger vessels viz., M.F.V. *Jheenga* (153 H.P.), M.F.V. *Meenabharathi* (260 H.P.) and M.T. *Kalyani's* III to V (300 H.P. each) of the Government of India Deep Sea Fishing Station were also fishing in this division using otter trawls. The latitude zone-wise abundance of prawns for the five year period 1963 to 1967 has been assessed and the results are shown in Fig.48. From 22° N latitude zone to 18° N latitude zone there is an increase in the maximum monthly catch rates, annual average catch rates and the percentage proportion of prawns. South of 18° N latitude zone, there is a fall in the catch rates of prawns in 17°, 16° and 15° N latitude zones. Of the 3 last zones, 16° N latitude zone is a shade better than the other two zones. Subareas 16-73/4B; 17-72/6F; 18-72/1C, 1D, 1E, 3D, 4D, 5B, 5C, 5D, 5E, 6C, 6D, 6E; 19-71/3F; 19-72/1C, 1D, 1E, 3A and 20-70/1D are very productive having given over 20 kg/hr; 15-73/2D, 3D;

NORTH-WESTERN DIVISION OF INDIA
REGIONAL ABUNDANCE AND PRODUCTIVE AREAS FOR PRAWNS
(N. I. F. BULL-TRAWLERS, 1957-'62)



ANNUAL LANDINGS

YEAR	CATCH kg	C.P.H kg	%
1956	12 204	4.28	0.53
1957	28 980	5.33	0.88
1958	15 210	3.00	0.42
1959	14 754	3.43	0.54
1960	22 338	4.32	0.52
1961	20 988	4.55	0.53
1962	38 604	9.78	1.09
1963	12 475	3.51	0.47
AVERAGE (1957-'62)	23 487	4.94	0.66

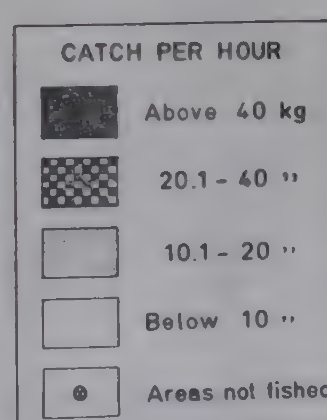


Fig. 47. Prawn landings in the North-Western Division of India fished by the commercial bull-trawlers for the period 1956-'63. Figure also shows productive areas for prawn in regions from Kutch to Bombay.

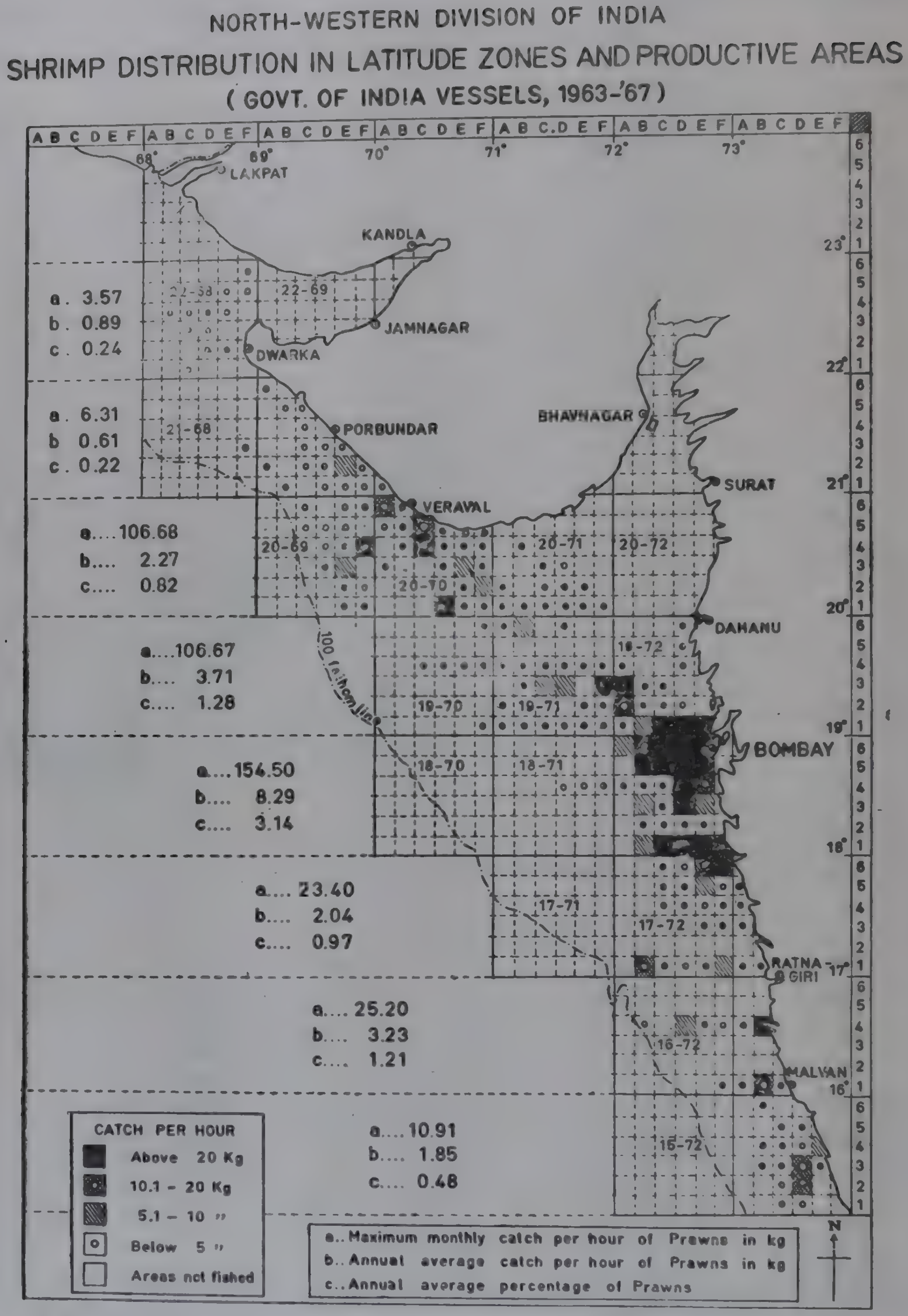


Fig. 48. Latitude zone-wise and area-wise abundance of prawns fished by the Government of India vessels of Bombay base for the period 1963–'67.

16-73/1B; 17-72/1B, 1E; 18-72/1F, 4E, 6B; 19-72/2A; 20-69/4F; 20-70/4C, 5C and 6A are good with 10.1 to 20 kg/hr; and 15-73/4E; 16-72/4D; 17-72/1F, 5E; 18-72/1B, 3B, 3E, 6A; 19-71/3C, 3D, 6B; 19-72/1B; 20-69/3E; 20-70/2F, 3E and 21-69/2E are fair giving 5.1 to 10 kg/hr. The rest of the areas fished have given below 5 kg/hr.

It may be seen that the zonal or regional catch rates obtained by the bull-trawlers are higher than those of the otter trawlers. In bull-trawling the catch per hour returns are for a pair of vessels and in otter trawling they are for a single vessel. It is well known that the catch per hour returns of bull-trawling are always higher than those of otter trawling (Jayaraman et al, 1959 and Rao et al, 1968).

Prawn landings at Bombay base by the Government of India vessels for the year 1966 give a fair picture of their major area-wise and seasonal abundance in the region. The vessels fished 29,982 kg of prawns forming 6.01% of the total marine fish catch, the annual catch rate being 12.86 kg/hr of trawling. The split up figures for each quarter are given in Table II.

TABLE II

Prawn landings by the Government of India vessels, Bombay base, 1966.

	1st quarter	2nd quarter	3rd quarter	4th quarter
Major areas fished	18-72, 19-72	18-72, 19-72	17-72, 17-73, 18-72	17-72
Prawn catch kg.	4,600	17,759	21,036	5,587
Percentage	4.22	14.07	3.84	2.64
Catch rate kg.	5.99	29.21	10.52	7.33

Some of the hauls from Bombay region have been good for prawns with very high catch rates; in Table III, particulars of all hauls with over 200 kg in each, fished by M.F.V. Jheenga in 1966 are given.

TABLE III

Particulars of hauls by M.F.V. Jheenga (153 H.P.) with more than 200 kg of prawns in 1966.

Area	Date	Duration of haul in hrs.	Prawn catch (C.P.H.) in kg.	% of prawns in total catch
18-72/6E	31-3-66	1.50	500(333.33)	70.13
,,	,,	1.50	501(334.00)	68.07
,,	,,	1.00	200(200.00)	63.29
,,	,,	1.25	230(184.00)	42.44
,,	1-4-66	1.50	350(233.33)	56.36
,,	,,	1.50	400(266.67)	54.35
18-72/6D	,,	1.50	437(291.33)	50.06
,,	11-4-66	2.00	300(150.00)	51.72
18-72/6E	,,	1.50	241(160.67)	53.92
,,	12-4-66	2.00	300(150.00)	47.92
,,	,,	2.00	335(167.50)	47.99
,,	15-4-66	1.50	200(133.33)	44.74
,,	16-4-66	1.50	200(133.33)	46.95
,,	,,	1.50	208(138.67)	51.23
18-72/6D	26-4-66	1.50	225(150.00)	27.95
18-72/5D	1-11-66	1.50	235(156.67)	25.82
18-72/6C	12-12-66	1.50	280(186.67)	34.57

The prawn fishery off Ratnagiri has come into prominence in the past nine years. In November 1959, a single haul of shore seine landed about 25 metric tons of prawns although in a few days the catches dwindled considerably. Since then, the region has been explored and exploited regularly for prawns. The grounds lie between Harnai in the north to Vengurla in the south in the inshore areas of Ratnagiri district, about 20 miles in width along the coast. The number of trawlers has increased in this region from 3 in 1961 to 27 in 1964. In a survey conducted with the help of 12 trawlers of the Fisheries Department of Maharashtra State from October 1963 to March 1964, a prawn catch of about 304 metric tons was obtained forming about 45% of the total catch. Prawn catch was found to

be better in Ratnagiri (23.6%) than in Malvan (14.13%) (Ranade *et al*, 1965).

Off Dabhol (17° 35' N) and Vengurla (15° 50' N) in depths from 16-22 metres, two of the larger vessels viz., *Akashi Marus* No.23 and 25 and the smaller vessels the *Sudhas* I to VI of the New India Fisheries Company, Bombay, during January - March 1967 landed about 145 metric tons of prawns. The overall catch rate for prawns in the quarter for the bigger vessels was 67.38 kg/hr and for the smaller vessels 77.90 kg/hr. Not only the catch rates but also the percentage proportion of prawns were higher for the smaller vessels (81.68%) as compared with those obtained by the bigger vessels (44.38%). During the year as a whole covering the areas north and south of Bombay, the New India Fisheries vessels fished 237,246 kg of prawns which formed 22.2% at a catch rate of 48.95 kg/hr. The southern grounds have proved to be extremely productive as in the first quarter of the following year (1968) the smaller vessels had obtained 190 metric tons of prawns forming 59.38% of the total catch at 93.31 kg/hr.

In the North-Western Division, the common prawn species landed by the trawlers are *Metapenaeus affinis* (Milne Edw.), *M. monoceros* (Fabr.), *M. brevicornis* (Milne Edw.), *Penaeus indicus* (Milne Edw.), *Parapenaeopsis stylifera* (Milne Edw.) and *P. hardwickii* (Miers). The less common ones are *Metapenaeus kutchensis* George *et al* from Kutch, *Solenocera indica* Nataraj, *Palaemon tenuipes* Henderson, *Penaeus penicillatus* Alcock, *P. monodon* Fabricius and *Hippolysmata ensirostris* Kemp from Bombay and *Penaeus merguiensis* de Man off Goa.

PRAWN LANDINGS IN SOUTH-WESTERN DIVISION

The best of the prawn fishing grounds of India are located in the southern part of this division. The particulars of prawn landings by the offshore fishing vessels operating from different bases in recent years are furnished below.

a) *Karwar* (Between latitudes 14° N to 15° N and longitude 73° 30' E to 74° 30' E): Exploratory fishing by the medium vessels of the Indo-Norwegian Project viz., *INP-167* (24 H.P.), *Karwar 1* (90 H.P.), *M1/M4*

(48 H.P.) was commenced in September 1963. In the years 1963-'64, 1964-'65 and 1965-'66 the vessels landed 11.3, 3.29 (data for one vessel not available) and 1.48 metric tons of prawns forming 6.66%, 2.2% and 1.29% of the total catches respectively, The major areas 14-73 and 14-74 have yielded fairly good catches of prawns, the latter being slightly better. 14-73/5F, 6F; 14-74/5A and 6A have been found to give good yields. The catch rates ranged from 8 to 62 kg/hr for the vessel Karwar-1, 5 to 92 kg/hr for M1/M4 and 5 to 18 kg/hr for INP-167. As shown in Fig.49 the maximum monthly catch rates of prawns obtained in the region for the period 1963-'67 is 225 kg/hr.

The common prawn species landed by trawlers in Karwar are *Metapenaeus affinis*, *M. dobsoni* (Miers), *Parapenaeopsis stylifera* and *Penaeus merguiensis*.

b) Mangalore (Between latitudes 12° 10' N to 14° N and longitude 73° 30' E to 75° E): The Government of India exploratory fishing vessels (M.F.V. Tarpon (42 H.P.), M.V. Samudra (42 H.P.) and M.V. Sagarvihari (42 H.P.))and a large number of mechanised boats of the Directorate of Fisheries of Mysore State have operated from this base providing information on the existence of rich prawn grounds in this region. The catch particulars are furnished in the Table IV.

TABLE IV

Prawn landings by the Government of India vessels and mechanised boats of Mangalore base, 1963-'64 to 1966-'67.

Year	Government of India vessels			Mechanised boats	
	Catch kg	C.P.H. kg	%	Catch kg	%
1963-'64	12,659	31.72	14.74	540,888.5	16.93
1964-'65	6,493	10.34	10.40	582,877.0	18.18
1965-'66	7,478	18.97	18.03	1135,948.0	28.87
1966-'67	..	..	..	1007,996.0	25.03
1967-'68	..	..	..	996,231.0	26.05

The Government of India vessels operated off Mangalore, Malpe and Coondapore. Some of the subareas in the two major areas viz., 12-74 and 13-74 have proved to be very productive. In 1963-'66 in some of the months from subareas 12-74/3E, 4E, 4F, 5D, 5E, 6E; 13-74/1D, 1E and 3D the catch rates for prawns were over 50 kg/hr up to 360 kg/hr. The catch rates (monthly maximum and annual average) and the percentage proportion of prawns in the total catches have been observed to be very much higher in this region than in Karwar (Fig.49).

The mechanised boats of the Fisheries Directorate operating in the inshore grounds at Mangalore and Malpe have landed quantities of prawns forming a big proportion in the total landings (Table IV). The prawn percentage in the total catch was higher at Mangalore (35%) than at Malpe (3.6%).

The common prawn species landed by trawlers in this region are Metapenaeus affinis, M. dobsoni, Parapenaeopsis stylifera and Penaeus indicus.

c) Cannanore (Between latitudes 11° 20' N to 12° 10' N and longitudes 74° 30' E to 73° 40' E):- The vessels of the Indo-NorwegianProject (Ashtamudi, Norind (48, H.P.) and M1/M4) explored the inshore region up to 20 fathoms. The operations were commenced in 1963. In 1963-'64, 66.16 metric tons of prawns were obtained which formed 49.72% in the total catch; in the following year 18.107 metric tons of prawn catch was obtained forming 19.66% of the total fish. In the subsequent years the landings by the Indo-Norwegian Project's vessels were still poorer. In the four year period the catch rates had shown a very much downward trend from 151.3 kg/hr in 1963 to 53.5 kg/hr in 1964, 16.3 kg/hr in 1965 and 27.7 kg/hr in 1966. Areas 11-75/5B, 5C, 6A, 6B and 12-75/1A had given monthly catch rates ranging from 25 to 73 kg/hr.

The mechanised boats operating in the region in 1966-'67 have obtained a fairly high estimated catch of 130.483 metric tons of prawns forming 32.85% of all fish; the yields were still better in 1967-'68, being 896.984 metric tons forming 67.31% of all fish.

The common prawn species landed by trawlers in Cannanore were *Metapenaeus affinis*, *M. dobsoni*, *Parapenaeopsis stylifera* and *Penaeus indicus*.

d) *Cochin* (Between latitudes 7° 30' N to 11° 20' N and longitudes 75° 50' E to 78° E): This region is well known for prawn grounds which are comparable to the world's best grounds in Mexico and the United States of America. Prawn fishing with indigenous non-mechanised craft and gear in the inshore region and the backwaters is an ancient occupation in Kerala, but the introduction of mechanised craft and particularly fishing with trawlers is more recent. In 1956 *Ashok* and *Pratap* (240 H.P. each) commenced trawling (bull-trawling) in the region, followed in the subsequent years by a number of other trawlers belonging to the Government of India, Offshore Fishing Station. Large and medium trawlers of the Indo-Norwegian Project and several commercial concerns, besides a number of smaller mechanised craft of the fisheries co-operatives and processing concerns are now regularly operating from this base for prawn fishing.

Bull-trawling operation by *Ashok* and *Pratap* in 1956-'59 period, in grounds between Cannanore and Wadge Bank have resulted in rather low yields of prawns which constituted about 1.3% of the total fish catches. In Table V are given the catch particulars of the prawns by some of the trawlers in recent years. A downward tend is seen in the catch rates of the prawns obtained by the Government of India vessels for all the years from 1963-'64 to 1967-'68. The Indo-Norwegian Project's medium vessels also showed a downward tend in the catch rates, but only up to 1965-'66 and then an increase. As compared with these results, the catch rates of prawns by the Cochin Company's vessels were more or less steady in the entire period, the reason being that these vessels were seeking to find productive grounds only for fishing.

In areas explored by the Government of India vessels for the period 1963-'66, the following graded pattern of catch rates was observed. In 9-75/5F and 9-76/5B the catch rates for prawns were over 40 kg/hr: in 9-76/2B, 4B, 6A, 6B; 10-75/1E, 5F; 10-76/1A and 11-75/1D the catch rates were ~~kek~~ from 21 to 40 kg/hr: in 9-75/6F; 9-76/1A, 1C, 4A, 5A; 10-75/1F, 4E;

10-76/1B, 4A; 11-75/1E and 1F they were from 10 to 20 kg/hr. Areas 8-76/4D, 4E; 9-75/6E; 9-76/1B; 10-75/2F, 3E, 3F, 4E, 5E, 6F; 10-76/2A and 11-75/1C gave below 10 kg/hr.

TABLE V

Landings of prawns in Cochin by some trawlers, 1963-'64 to 1967'68

	1963-'64	1964-'65	1965-'66	1966-'67	1967-'68
Govt. of India vessels:					
Catch kg	44,160	27,508	18,587	40,626.5	12,947.5
Catch/hr. kg	47.01	19.61	15.80	16.50	9.65
Percentage	37.01	17.16	14.13	20.57	11.65
INP median vessels:					
Catch kg	20,323	3,546	3,901	25,730	103,334
Catch/hour kg	23.49	17.04	13.96	14.28	23.00
Percentage	20.68	14.21	13.17	25.59	44.96
INP larger vessels:					
Catch kg	...	...	...	19,992	41,526.5
Catch/hour kg	...	...	...	30.75	34.07
Percentage	...	...	...	27.38	12.80
Cochin Company's vessels:					
Catch kg	...	14,112*	55,168	88,856.5	59,207
Catch/hour kg	...	18.38	20.69	24.83	23.12
Percentage	...	9.16	27.90	36.62	45.67

* 3 months fishing only.

The research vessels Kalava (120 H.P.) and Varuna (400 H.P.) and some of the larger exploratory fishing vessels viz., Klaus Sunnana (220 H.P.), Tuna and Velameen (480 H.P. each) of the Indo-Norwegian Project fishing in the deeper waters beyond the continental shelf have landed prawn species *Aristeus semidentatus* (Bate), *Penaeopsis rectacuta* (Bate), *Metapenaeopsis* spp., *Parapandalus spinipes* De Man, *Plesionika martia* (A.M. Edw.), *Heterocarpus gibbosus* (Bate), *H. wood-masoni* Alcock, *Oplophorus gracilorostris* A.M. Edw., etc. the existence of which was hitherto not known. Some of the

species were found in dense populations to support fisheries if the grounds are further explored and carefully exploited (George, 1966; George & Rao 1966; Menon 1968).

The productive areas fished by the larger INP vessels giving monthly catch rates of over 200 kg/hr of prawns in the period 1967-'68 in the region between Alleppey and Quilon are given in Table VI.

TABLE VI

Productive areas giving over 200 kg/hr, fished by INP larger vessels 1967-'68.

Area	Vessel	Month	Depth (metres)	Catch/hour (kg)
8-75/5D	Klaus Sunnana	December '67	289	285.00
8-75/5E	Velameen	February '68	348	260.50
8-75/6D	,,	January '68	342-353	273.33
8-75/6E	,,	,,	342-346	214.44
9-75/1E	Klaus Sunnana	December '67	320-358	248.57
,,	Tuna	January '68	351-366	309.64
,,	Velameen	February '68	348	244.09
9-75/1F	Tuna	December '67	344-366	415.93
,,	,,	January '68	366-369	206.31

The New India Fisheries Company's vessels at Cochin base in the five year period from 1963-'64 to 1967-'68 have landed 11, 442 metric tons of prawns and fish sold at about Rs.2.82 crores. The annual average landings were 2, 288 metric tons.

It may be mentioned here that usually very heavy prawn catches are landed by the mechanised boats at Azhikode fishing centre also. In 1962-'63 a prawn catch of 449.4 metric tons was landed at 50.35 kg/hr forming 73.0% of the total; the corresponding figures for 1963-'64 being a catch of 159.8 metric tons at 37.97 kg/hr forming 70.73% (Data C.M.F.R.I. Annual Reports 1962-'63 and 1963-'64).

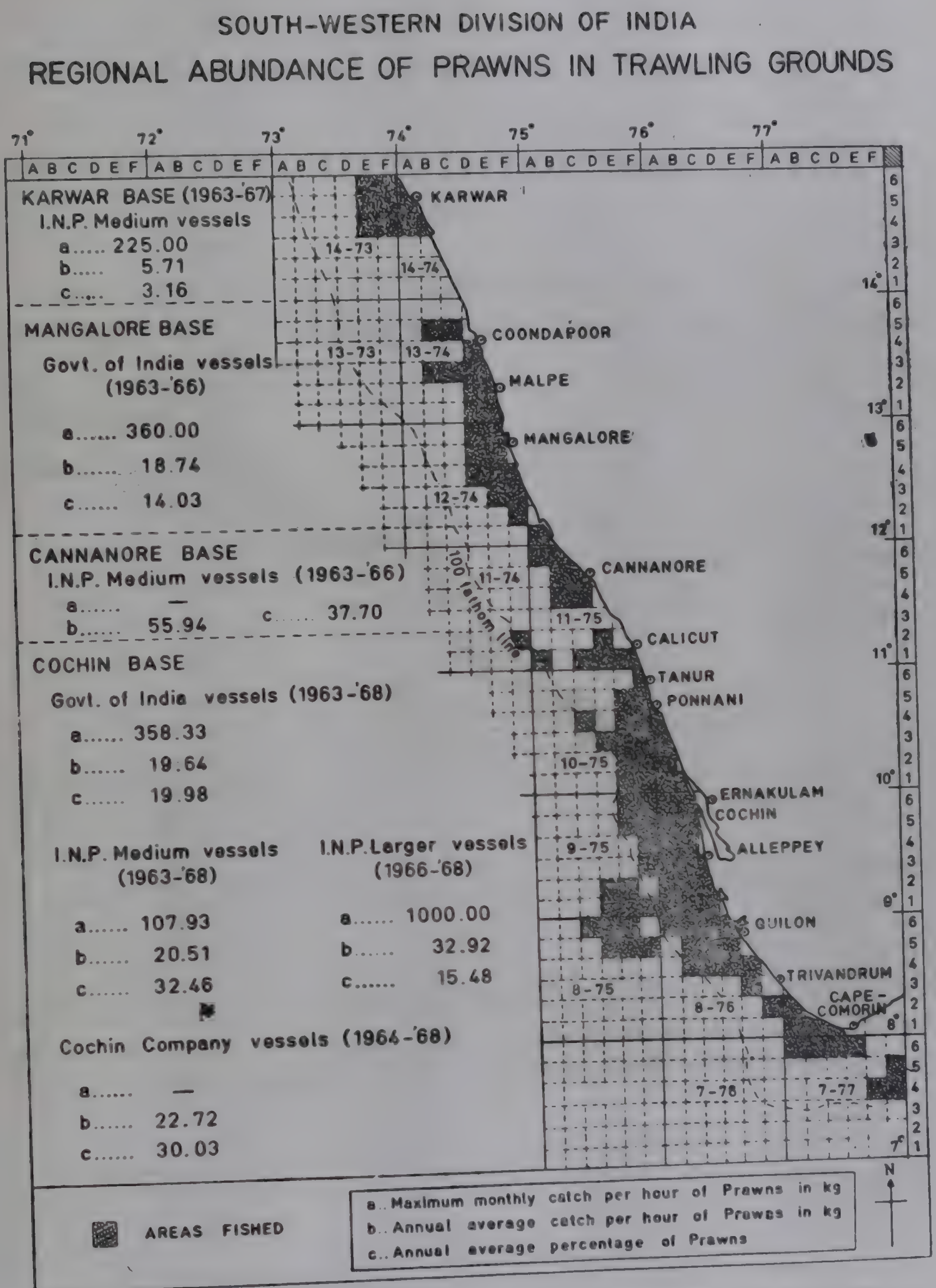


Fig. 49. Regional abundance of prawns in trawling grounds of the South-Western Division of India from Karwar to Cape Comorin.

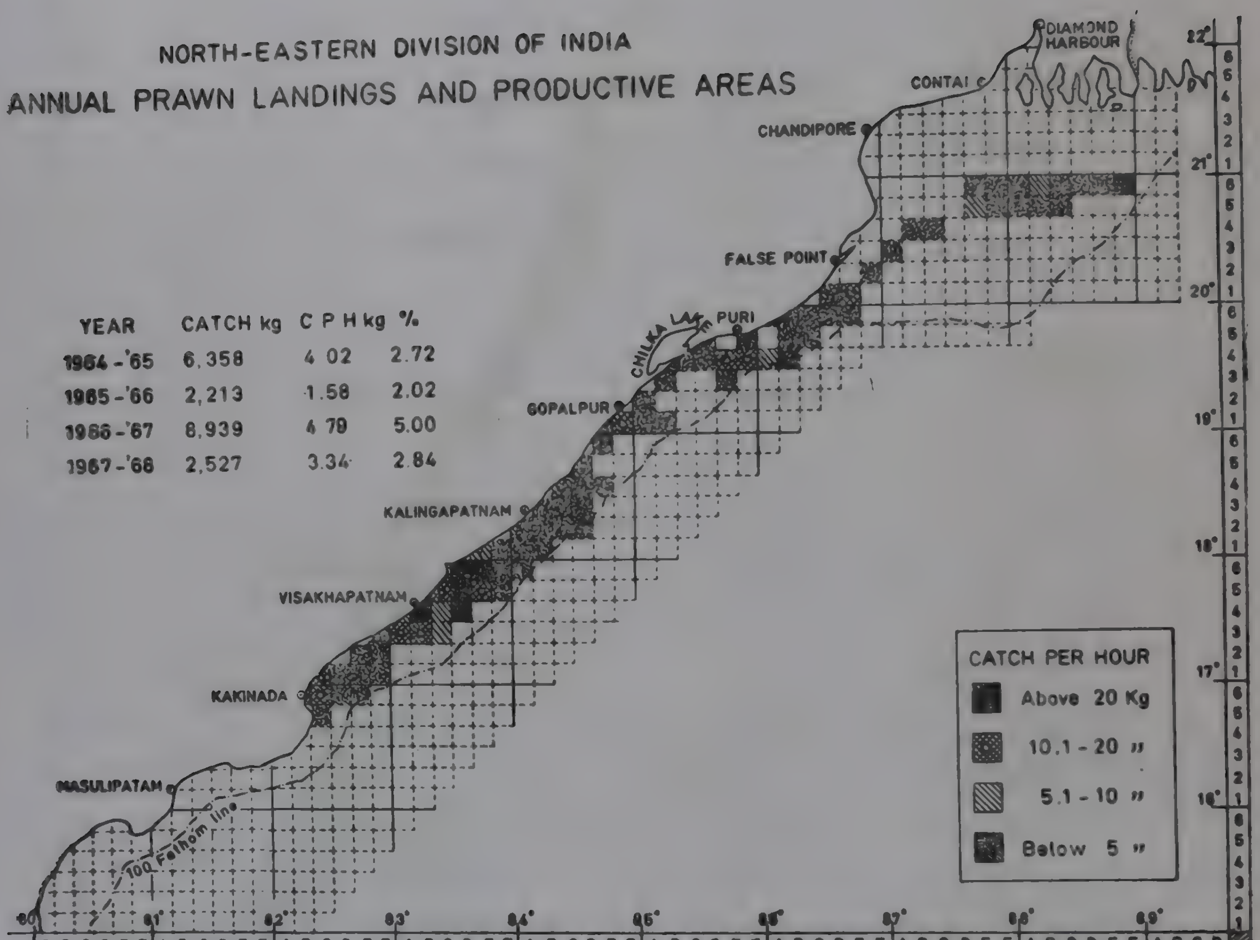


Fig. 50. Prawn landings and productive areas revealed by the Government of India vessels in the North-Eastern Division for the period 1964–'68.

All the areas covered by the powered fishing vessels operating from Cochin base for the period 1963-'68 are shown in Fig.49. The maximum monthly catch rates of prawns for the different groups of vessels are very high. The highest catch rate registered by INP larger vessels is 1000 kg/hr. The annual average catch rates and the percentage of prawns in total catches are also very high, but they seem to rank next to the corresponding values obtained by vessels which operated from Cannanore base. Cochin is undoubtedly the best region for prawn grounds. In this region the vessels have operated almost all round the year except when the weather was very unfavourable during monsoon whereas in Cannanore fishing during the years for which the averages have been estimated was confined to the seasons in which the prawns were best obtained. Further during 1963 the catch rates at Cannanore were exceptionally high (151.3 kg/hr), although in subsequent years the annual catch rates ranged only between 16.3 kg/hr and 53.5 kg/hr. It is due to these differences that the annual average catch rates and the percentage proportion of prawns are found higher from Cannanore than in Cochin.

The common species supporting marine prawn fishery at present in Cochin region are *Metapenaeus dobsoni*, *M. affinis*, *M. monoceros*, *Penaeus indicus* and *Parapenaeopsis stylifera*. It may be noted that the giant prawn *Macrobrachium rosenbergii* (de Man) does not support a fishery in the coastal or offshore waters, although fairly common in backwaters and rivers.

PRAWN LANDINGS IN SOUTH-EASTERN DIVISION

The marine fish catch of the east coast is only about a fifth of the total catch from both the east and west coasts. Prawn landings too are considerably less on the east coast forming only about 10% of the total prawn production of India. However, fairly good prawn grounds are now known to occur in several regions on east coast as revealed by the trawling operations of vessels belonging to different agencies.

a) Tuticorin: With Tuticorin as the base of operations, the vessels of the offshore fishing station of the Government of India which was

opened in 1959, surveyed trawl fishing grounds (latitude 8° N to 12° 10' N and longitude 77° E to 81° E) in the vicinity of Tuticorin (Major areas 8-78, 9-78 and 9-79) and Pondicherry (major areas 11-79, 11-80, 12-79 and 12-80). In the period from 1960-'66 good prawn catches were obtained only from the major area 8-78 near Tuticorin. Possibly some good grounds may be near Pondicherry region also but the few operations carried out so far did not reveal any productive areas.

The Government of India fishing vessel M.V. Sagarsundari (42 H.P.) during 1966-'67 obtained 19,492 kg of prawns at 29.11 kg/hr forming 12.07% and in 1965-'66 a catch of 4,670 kg at 8.21 kg/hr forming 5.59% of the total catch. In 1966-'67 the subareas 8-78/4B proved to be very good with an annual catch rate of 30.63 kg/hr, followed by 4C with 19.24 kg/hr and 5B with 3.21 kg/hr. In 1965-'66 prawn yield rates in the respective areas were 19.12 kg/hr, 6.51 kg/hr and 1.71 kg/hr. Prawns being of good size for export trade and the yield rates being high in some of the earlier years there was in the year 1967-'68 a more intensive exploration, some of the vessels from Bombay having been shifted to this base for the purpose. However, there was a fall in the total catch (9,958 kg), catch rate (4.94 kg/hr) and the percentage proportion (3.53%) of the prawns fished by the vessels; the highest monthly catch rate was only 20.32 kg/hr. These results appear to indicate that the high yields of prawns are rather sporadic than regular in this region.

b) Mandapam: The medium vessels of the Indo-Norwegian Project using shrimp trawls fished up to 20 fathoms depth in Palk Bay (latitudes 9° 20' N to 9° 40' N and longitude 79° E to 79° 10' E) and the Gulf of Mannar (latitudes 8° 50' N to 9° 15' N and longitude 79° E to 79° 30' E). In 1965-'66 the total catch by two vessels was 175,663 kg of which prawns formed about 1%. Prawns from the Gulf of Mannar region formed 1.41% and from the Palk Bay region 1.05% of the total regional catches. In 1966-'67 the total catch by trawling was 54,929 kg of which prawns formed 0.95%. After March 1967 the vessels stopped fishing operations from this base. 5 to 20 kg/hr of prawns were obtained from a large number of areas in the Gulf of Mannar (8A, 9A, 9B, 10A, 10B, 14B, 15B, 15D, 16D and 17C) and from very few only in the Palk Bay (2A and 3A).

In the South-Eastern Division *Penaeus indicus*, *P. monodon*, *Metapenaeus dobsoni*, *M. affinis* and *M. monoceros* are the common species landed.

PRAWN LANDINGS IN NORTH-EASTERN DIVISION

As compared with the South-Eastern Division, this division is slightly better for prawn yields in offshore fishing grounds. Fairly productive grounds off Kakinada, Visakhapatnam and in the vicinities of Chilka Lake have been located in the exploratory fishing operations. However, intensive offshore fishing surveys for prawns using shrimp trawls have not so far been undertaken in this region.

a) Kakinada: Experimental shrimp trawling with 30 and 32 ft. mechanised boats with 30 and 45 H.P. engines have been tried off Kakinada by the Research Unit of the Central Institute of Fisheries Technology and the Training Institute of the Andhra State Fisheries Department in grounds between latitudes 16° 50' N & 17° 10' N and longitudes 82° 20' E & 82° 30' E. Grounds which are fairly productive off Uppada and Hope Island have been located (Anon; 1967). Some of the catch particulars of prawns are given below.

Year	Results of operations by boats of					
	Central Institute of Fish. Tech.			Training Institute of A.S.F.D.		
	Catch kg	C.P.H. kg	Percentage	Catch kg	C.P.H. Kg	Percentage
1964	7,304.5	11.75	22.83	5,927	9.39	18.11
1965	8,806	15.45	20.00	40,103	3.99	14.11
1966	5,887	9.66	28.07	3,512	5.29	12.08

b) Visakhapatnam: Since 1959, when the Offshore Fishing Station was opened, the Government of India fishing trawlers have explored the fishery resources of a long strip of continental shelf, off the coast of Andhra and Orissa States, between the river mouths of Godavari and Mahanadi. In the annual landings by trawlers prawns formed 2 to 3% of the total catches. In 1966-'67 the prawn landings were much higher than in the previous years.

The annual landings of prawns, their catch rates and the percentage proposition in total landings are given in Fig. 50. The latitude zone-wise maximum monthly catch returns are given below.

Year	Latitude zone	Highest monthly catch/hour kg
1964-'65	17° - 18° N	9.40
	18° - 19° N	13.57
	19° - 20° N	13.50
	20° - 21° N	4.20
1965-'66	16° 40' N	3.00
	17° 40' N	6.80
	18° 10' N	7.13
1966-'67	17° 40' N	13.10
	18° 10' N	22.20
1967-'68	17° 40' N	25.10

There is in general an increase in prawn landings from southern to northern latitude zones. Grounds in the vicinity of Chilka Lake in the latitude zone 19° - 20° N and those in the next below southern latitude zone of 18° - 19° appear to be fairly productive.

Based on the results of the Government of India fishing vessels operating from this base during March 1963 to April 1968, the productive areas for prawns are shown in Fig.4. In some months areas 17-83/4B, 4D, 5D, 6D, 6E and 20-88/6F have given over 20 kg/hr of prawns: 17-83/3A, 3B, 5C, 5E; 18-84/4C, 5D; 19-84/1F; 19-85/4E, 4F and 20-86/1E between 10.1 and 20 kg/hr and 17-83/3C, 4A, 4C; 18-82/1E; 19-86/4A; 20-87/5E and 20-88/6B between 5.1 and 10 kg/hr.

c) <u>West Bengal</u>: From 1950-'51 to 1961-'62 two Danish cutters and three Japanese type of trawlers (M.T. <u>Kalyanis</u> I to V - 300 H.P. each) of the Directorate of Fisheries of the West Bengal were used for intensive surveys and commercial exploitation of the fishing grounds off Gopalpur in the south to Diamond Harbour and adjacent areas in the north. Fairly productive grounds have been found for demersal fishes in general but not for

prawns. In 1957 the prawn yield was 6.1 metric tons (forming 1.26% in total catch) at 235.11 kg/voyage; in 1958, 6.3 metric tons (1.81%) at 204/ kg/voyage and in 1959, 1.4 metric tons (0.55%) at 64.42 kg/voyage.

Based on observations made on board the vessels in 1960, it has been found that proportion of prawns in the regional catches was the highest being 2.22% in the Eastern Channel (latitude 20° 52' N to 20° 55' N and longitude 88° 05' E to 88° 30' E), followed by 1.73% and 1.23% in the landings from the grounds, off Debi-Prachi Rivers (latitude 19° 54' N to 20° N and longitude 86° 27' E to 86° 30' E) and Western Channel (latitude 20° 50' N to 20° 55' N and longitude 87° 50' E to 87° 52' E) respectively; prawn percentage was poor being 0.5 in grounds off Mahanadi (latitude 20° 05' N to 20° 11' N and longitude 86° 35' E to 86° 47' E) and 0.69 off Black Pagoda (latitude 19° 45' N to 19° 49' N and longitude 86° 11' E to 86° 24' E).

In the North-Eastern Division as a whole, *Penaeus indicus*, *P. monodon*, *P. semisulcatus* Alcock, *Metapenaeus dobsoni*, *M. affinis*, *M. monoceros*, *M. brevicornis*, *Parapenaeopsis sculptilis*, *Solenocera indica* are common.

CONCLUSION

The major component of the prawn landings by the mechanised vessels is constituted by the penaeid prawns which as far as is known spend their life histories in two environments viz., the marine and the estuarine or brackishwater environments, exception to this being *Parapenaeopsis stylifera* which spends its entire life in the marine environment. Other penaeid prawns like *Penaeus indicus*, *Metapenaeus affinis*, etc. breed in the sea either in the shallow water or a little beyond in the deeper waters. The eggs, larvae and post-larvae of most species are found abundant in the inshore waters in certain seasons. The younger stages migrate to the estuarine or brackishwater environments, where they grow to fairly large size and migrate back into the sea, where sexual maturity is attained for spawning to complete the life cycle. Because of these migratory habits the abundance of penaeid prawn resources is relatively much higher in the

shallower depth zones of the inshore than in the very deep waters. Rao *et al*, (1968) have stated that high catch rates for prawns were observed from the shallower and also the deeper depth zones up to 80 metres in some of the latitude zones in the Bombay-Saurashtra waters, but taking all latitude zones together the relatively greater abundance of the prawns was from the shallower grounds up to 30 metre depths. The results of bottom trawling in the Indian seas by R.V. *Anton Brunn* have also shown that the prawn catches were mostly from shallower depths (Hida and Pereyra, 1966).

In Cochin region the major portion of the catches of prawns come from the shallower depth zones up to 24 metres, the highest prawn percentage observed being from 15 to 19 metre depth zone (Rao, 1968). There seems to be also variation in the species distribution in the different depth zones. In depths from 14 to 20 metres *Metapenaeus dobsoni*, *Parapenaeopsis stylifera*, *M. affinis*, *M. monoceros* and *Penaeus indicus* were in the order of abundance, whereas in depths between 21 to 27 metres *Penaeus indicus* dominated over *M. monoceros* and *M. affinis*. In still deeper waters up to 35 metres *P. indicus* and *M. affinis* were of equal abundance (Annual Report, CMFRI, 1967).

The contribution of non-penaeid prawns Like *Palaemon tenuipes* to the inshore fishery especially in the north-western regions is fairly high but their proportion in the offshore fishery is very negligible. That the pandalids like *Parapandalus spinipes* along with a few other deep sea prawns as stated earlier occur in depths beyond 100 fathoms in some concentrations is now well established but the extent to which they can be harvested yet remains unexplored.

Regarding the fishing season for prawns in the inshore waters Mohamed (1967) states that the period generally extends on the west coast from November to May and on the east coast from December to August. Fishing is generally suspended during the monsoon but in the Gulf of Kutch and in the regions where there is formation of 'Mud Banks' in Kerala, some good catches of prawns are obtained even during monsoon months. In the offshore fishing grounds from Bombay to Kutch, Kagwade (1967) states that the prawns occur throughout the year but the catches begin to increase

from March onwards, the best months for fishing being July to October and in some regions extending even up to December. Rao *et al* (1968) states that in the offshore fishing ground in the latitude zone from 15° N to 22° N in the north-western division prawns generally show two peaks, the first in April-May and the second in about October. The seasonal pattern of movements in different depth zones in the annual cycle for some of the regionally important penaeid prawn species is given by George *et al* (1968). For instance in *M. monoceros* the offshore migration commences from November and by about April those above 80 mm size move into the depth zones 9.1 to 18.3 metres and by June all around 95 mm size move into the deeper waters of 18.3 to 27.4 metres. It has also been observed that in still deeper waters prawns of large size only have been encountered. *P. stylifera* which does not enter the backwaters at all in its life history, is comparatively more abundant in deeper waters up to November but gets dispersed subsequently to shallower zones.

The efficiency of the gear is one of the main factors determining the catch per unit effort. The types of gear used in exploratory fishing operations, detailed in the earlier section, are varied. The New India Fisheries Company's vessels from Bombay base were operating the bull-trawls, the specifications of which are given by Kagwade (1967). The Government of India vessels at various bases were using mostly otter trawls and in a few cases of shrimp-trawls. These are of varied specifications suited to different types of vessels using them, the details of which are given by Rao *et al* (1968) and Rao (1968). The Indo-Norwegian Project's vessels at all bases were operating mainly shrimp-trawls. For comparison in this paper the results obtained by similar types of vessels only are taken into consideration for assessing the regional abundance. The recent findings have shown that the efficiency of the gear can be considerably increased by suitably modifying some of the specifications of the gear (Kurian, 1965). By attaching a tickler chian to a 10 foot beam trawl net, it was found that the catch of the prawns increased by 47%, but this had no effect on the fish catches. To the otter trawls the attachment of the tickler chain increased the prawn landings by

71%. The increase in catch is apparently due to the disturbance caused by the movement of the chain attached to the foot rope (Anonymous, 1962). The dragging of the heavy iron chain for scaring the prawns has been in vogue in prawn fishing in Kerala backwaters (Panikkar and Menon, 1956). The prawn catches in an otter trawl were more when the number of floats attached to the net was less, bringing about a comparatively less bouyancy on the head rope. When additional wings were attached to the otter trawls a 50% increase in the prawn catch was noticed, but this needs confirmation as the results obtained from different regions showed significant differences (Kurian loc. cit.).

It has also been found that for a shrimp trawl a deep belly is not necessary and that by reducing it by one-third, a considerable saving of the nylon or cotton can be effected without decreasing the efficiency of the trawl (Mhalathkar and Krishna Iyer, 1967).

The rapid introduction of small, medium and larger types of trawlers in the Cochin region has no doubt increased the total volume of the prawn landed in recent years, but the catch per unit of effort has condierably decreased. Very recently the exploratory and commercial fishing operations have shown an abundance of economic varieties of prawns in the grounds off Bombay, Ratnagiri and Goa. Instead of increasing any further fishing effort in Cochin region it is desirable that the as yet not adequately exploited resources elsewhere are tapped to a greater extent than is obtained at present. It is generally stated that the facilities for handling the catches at these newly discovered centres are sadly lacking. If adequate facilities for cold storage, freezing and processing are provided at Bombay, Ratnagiri and Goa the locally available resources can be satisfactorily exploited to earn the much needed foreign exchange.

IX PRAWN FISHING METHODS

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IX PRAWN FISHING METHODS

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Before 1950 the prawn fishery was exploited only within a narrow coastal strip of 5-20 m depth by various types of indigenous gears. Later, due to the introduction of mechanised fishing vessels the commercially exploited grounds have extended up to 40 m depth. Besides trawling, the conventional gears constitute an important source of prawns landings. There is however no comprehensive account of the different methods of prawn fishing in India except for brief references by Panikkar and Menon (1956) and Venkataraman _et al_ (1956). The other available information is related to fishing methods in general or to prawn fishing methods in specified regions (Hornell, 1925 and 1938; Rai, 1933; Chopra, 1939; Naidu, 1942; Jones and Sujansinghani, 1954; Nayar, 1958; George 1961; Menon and Raman, 1962; Thyagarajan and Thomas, 1962; Mani, 1963; Pillai and Ghosh, 1962). It is therefore attempted to deal, in the present account, with the methods adopted for capture of prawns on the Indian coasts, besides those in the backwaters and estuaries which yield a sizable prawn fishery. The types of fishing implements used for catching prawns along the Indian coast depend largely on the physical characteristics of the coast line and the habits of the species.

FISHING CRAFTS

A variety of indigenous crafts is employed in prawn fishing from the simple catamarans of the east coast to the well-built canoes of the Maharashtra coast. The diversity of these crafts calls for a detailed study. Zeiner and Rasmussen (1958) have dealt with the various types of boats of the Indian coast for designing motorised crafts.

The prawn fishing crafts of India can be classified into: (a) catamarans, (b) canoes of the dug-out and plank-built types, (c) carvel type plank-built boats and (d) modern crafts such as pablo boats and large steel trawlers.

Catamarans:- They are non-rigid types of crafts of variable dimensions, used on the surf-beaten coast, for operating boat-seines with a crew of 2-4 men. The primitive one consisting of 4 to 5 logs tied together in a raft fashion is prevalent on the west coast from Quilon southwards till Colachel where from the improved variety boat-catamarans appear and continue to occur in the Gulf of Mannar region. The later variety of craft varies little in size (6-7 x 0.75 - 0.9 m) and is made of 3 logs, the central one being the stoutest, fitting keel-wise at a lower level than the other two which rise sufficiently on each side to form a trough shaped hollow in between. The coromandel type of catamaran is found from Point Calimere to Krishna Delta. It is constructed either of 3 logs (chinnamaram - 6.3 x 0.7 m) or of 4 logs (Periamaram - 7.6 x 1.0 m), the middle logs in both projecting aft beyond the outer logs. Another type, Teppa or Teppalu (6.6 x 1.4 m) is in use north of Krishna and Godavary deltas. It is boat-shaped and consists of 2-3 median logs with two smaller ones on the outer sides. In the Orissa and Ganjam coast, the catamaran (4.2 - 5.7 x 0.75 - 1.0 m) has 3 median logs to which two rows of smaller pieces are pegged on the outer sides.

Canoes:- The most common fishing vessel found all along the west coast is the dug-out canoe ~~(Plate I-B)~~ variously known as Vallom, Odam, Hodi, Thoni etc. in different regions. It is made by hollowing out a single log of wood and is of varying sizes (6.10 x 0.5 - 1.25 x 0.45 - 0.7 m). It is employed for operating boat-seine, shore-seine, gill-net, cast net and occasionally trawl nets with a crew varying from 2 to 8 men. In the backwaters of south-west coast smaller canoes (3.6- 4.5 m in length) are used. The outrigger type plank-built canoes (7 to 14 m long, 0.9 to 3.0 m beam and 0.6 to 1.8 m draft) which are essentially dug-out canoes with planks stitched to the sides are in use in the Malabar, Kanara and Konkan coasts for shore-seine operations.

Out-rigger dug-out canoes are employed for cast net fishing in the backwaters near Cuddalore and Porto-Novo. Flat-bottom canoes - shoe-thoni of dimensions 9.5 x 1.6 x 0.7 m ~~(Plate-II-A)~~ and the Malia type (5.4 - 6.6 x 0.9 - 1.3 x 0.5 - 0.6 m) are in use for stake-net fishing in the Godavary estuary and the creeks of the Gulf of Kutch respectively. In the Chilka and Pulicat lakes and Madras backwaters clinker-built reproductions of dug-out canoes are seen.

Plank-built boats:- They are sturdy boats, prevalent north of Ratnagiri District and Point Calimere on the west and east coasts respectively. The Hodas (6.6 - 7.8 x 0.9 - 1.2 x 0.6 - 0.9 m) and Madhwad type Wahans (9.6 - 12 x 2.1 - 3.1 m) of Saurashtra coast and the Machwa (9 - 14 x 2.7 - 3.3 x 0.9 - 1.0 m) of Maharashtra coast are employed for bag-net fishing. They are manned by 7 - 9 men and are considered to be the best indigenous fishing boats for mechanisation. Many of them are fitted with 15- 30 H.P. engine. The Masula boat known as Padagu, Padava or Bar in different regions is found from Point Calimere northwards to Orissa except between Kakinada and Masulipatnam and is constructed with planks seen together by coir rope and is without any ribs or frames. It is mainly used for drag-net operations. The length of the boat ranges from 8.5 to 12.2 m. with a beam of 2.4 m. and depth of 1.2 m and the crew consists of 8-12 men.

Between Kakinada and Masulipatnam a rigid type of boat called Nava with a frame of strong ribs on which planks are nailed is employed for shore-seine, boat-seine and gill-net operations. The size of these boats is variable (6.4 - 10.7 m in length, 1.7 - 1.95 m in width and 0.6 - 0.84 m in depth), the bigger ones being used for shore-seine operations. The Nava used in the creeks and backwaters for drag-net operations has a smaller draft (0.4 m). The Dinghi of North Orissa and Nauka of West Bengal are carvel-built boats. The latter has variable dimensions (10.4 to 13.2 x 1.3 to 2.6 x 0.5 to 1.1 m) and is used in the bag-net operations in estuaries.

Modern crafts:- To explore new fishing grounds with improved gear and to increase the range and duration of fishing, mechanisation of some of the conventional boats like the machwa with necessary alterations

was accomplished in 1950. Thereafter, new types of fishing boat designs were introduced like the Dan boats (6.6 x 2.2 x 1.0 m), Pablo boats (7.4 x 2.1 x 1.05 m) and the shrimp trawlers (9.6 x 3.0 x 1.2 m). The horse power of these boats ranged from 10 to 60. The larger ones are partly or fully decked and have trawling winches. Since 1956 the number of mechanised boats has increased rapidly and it is now estimated that more than 6000 of them are combing the depths of the Indian coasts. Large-scale exploratory and commercial fishing operations are also conducted from different bases by a few large steel trawlers (14.3 - 30.9 x 5.1 - 6.3 x 1.6 - 3.3 m) belonging to several organisations like the Govt. of India Deep-sea Fishing Station, Indo-Norwegian Project and the New India Fisheries Ltd. They are fitted with engines of 90-300 H.P. and a refrigerated fish hold of 50-70 tonnes capacity.

FISHING GEAR

As in the case of the fishing crafts, a variety of devices from the primitive cover pots (plunge basket trap) to the modern shrimp trawl is employed for capturing prawns. Taking into consideration their mode of operation and the manner in which prawns are caught they can be ~~xxx~~ classified into the following categories.

1. Fixed or stationary nets

These include the bag-nets and stake-nets, which are operated in regions of strong tidal flow and hence the prawn catch is santy from 7th to 11th and 22nd to 26th day of the lunar month.

Bag-nets operated on the west coast:- The bag-nets constitute one of the important gears for prawn fishing and are extensively used in Bombay (locally known as *Bokshijal* and *Dol*) and Gujarat coasts (*Gholu Jal*, *Golva*, *Dor* or *Dol*). In the former region it is operated almost throughout the year while in the latter it is mostly used during the post-monsoon months till the commencement of summer. Prawns are caught along with Bombay-ducks, sciaenids, pomfrets, *Coilia* sp., *Polynemus* spp., seer-fishes etc. In the Bombay waters *Acetes indicus*, *Palaemon tenuipes*, *Metapenaeus affinis*, *Parapenaeopsis stylifera*, *P. hardwickii*, *Solenocera indica*, *Hippolysmata*

ensirostris and *Atypopenaeus stenodactylus* are netted in some quantities while in the Gujarat coast the prawn catch comprises mainly of *Metapenaeus kutchensis*, *M. brevicornis* and *Parapenaeopsis sculptilis*.

The bag nets of Bombay and Gujarat have been described by Setna (1949) and Pillai (1948) and Gokhale (1957) respectively. They are conical in shape, made of cotton or hemp, with a wide rectangular mouth. The size of the net is considerably variable, 12 to 200 m. long from mouth to cod end, mouth being 5 to 90 m. in circumference and mesh 1.0 cm. at the cod end progressively increasing to 4 to 12 cm. near the mouth. The entire net is made of 1 to 5 pieces. The bigger nets are operated in deeper waters. The *dol* net is operated in two different manners known as *Sus fishing* and *Khunt fishing*. The first method is employed in the Saurashtra coast and the second method in Maharashtra coast. The difference in these methods lies in the technique adopted to anchor the net and keep its mouth open. In *sus fishing* ~~(Fig.4)~~ the ropes from the four corners of the mouth of the net are tied securely either to two enormous spikes driven 45 m. apart into the muddy bottom in shallow regions or to two heaps of stones of 1000-1800 kg each in deeper areas. There are 2 or 3 large wooden floats attached to the upper lip of the mouth. Thus the mouth is kept open by flats and ropes. The net fishes at the bottom. In *khunt fishing* ~~(fig.5)~~, no floats and stone anchors are used. Two stout upright poles each of 40 m length, driven firmly into the muddy sea bottom, are used to set the net. The posts project about 3 m above the surface at flood tide. Two loop-like contraptions are slung on each post, a rope of the depth of the mouth linking them. Through these loops is passed another length of rope which carries a stone weight at its lower end. The upper end of the rope is wound round the pole projecting above the water surface. Each corner of the mouth is tied to a loop and the mouth of the net can be raised or lowered depending upon the level of the tide or fish movements. Unlike in *sus fishing* the net fishes a few fathoms above the bottom. The net, in either types of fishing is set to face the tide, either ebb or flood. One boat can usually operate a number of nets tied in series - 2 or 3 when they are set to stone anchors and 4 or more in the case of nets tied to stakes. The boat remains tied to the poles or the buoys as the case may be and the catch is periodically removed from the cod end. To avoid predation on the cod end catch, a subsidiary oval bag-net is tied to

the cod end. A light pole attached to the upper edge of the subsidiary net keeps it open in which predators get caught.

In the creeks of Saurashtra-Kutch region a smaller net *Gunja* (5 m long, $2\frac{1}{2}$ m wide at mouth with mesh 2.5 cm near the mouth decreasing to 1.0 cm at the cod end) tied to stakes as in the case of *khunt fishing*, is vogue for prawn fishery (*M. kutchensis*) particularly during August-October. In the backwaters of south-west coast of India prawn fishing is conducted almost throughout the year by *Valuvala* or *oonivala* - a conical bag-net of about 15 m long and mouth 18 m in circumference and made of cotton except the part bordering the mouth which is of ~~cotton except the part bordering the mouth which is of~~ coir yarn. The mesh size is variable from 1.0 cm at the cod end to 2.5 cm at the mouth (Hornell 1938 and Menon and Raman 1962). The net is set in position on a pair of stakes driven into the bottom mud, before or just after the commencement of ebb tide, and haulpd up when the high tide sets in. The species caught are *Metapenaeus dobsoni*, *M. monoceros* and *Penaeus indicus*. During the prawn cultural operations in the extensive paddy fields adjoining the backwaters of Kerala, juvenile prawns are collected by a conical bag-net (5-7 m long, mouth 1.5 to 2.0 m wide and mesh varying from 0.3 to 1.0 cm) tied to the outside of the sluice gate, kept open after full tide. Fishing is done at nights and often a powerful light is kept at the gate to attract prawns.

Bag-nets operated on the east coast:- The bag nets constitute by far the most important gear for prawn fishery in the tidal estuaries and creeks. They are operated in the Upputeru river leading into the Kolleru lake in the Gowthami, Vainetheyam and Vashista estuaries of the Godavary and the innumerable creeks connected with them, in the Kakinada Bay and in the lower reaches of the Hooghly and Matla estuaries.

Those employed in the Godavary and Krishna deltas (*Thokavala* or *Gidasavala*) resemble the *Valuvala* of Malabar backwaters in construction and mode of operation. The mesh size decreases from 10 cm near the mouth to 1 cm at the cod end. The net is 13.7 m long. The dimensions of the rectangular mouth are as follows: Head-rope 5.08 m, sides 3.8 m and foot-rope 5.9 m. The foot-rope, because it is longer than the head-rope,

forms a shallow bight while fishing which prevents the foot-rope from lifting off the bottom. To withstand the force of the tidal current the head-rope is sometimes moored to an anchor, placed in front of the mouth by two ropes. A number of nets (10-30) is operated in a row across the creek or estuary ~~(Plate III.A)~~. The nets are set at the turn of the high tide and the out-going tidal flow is filtered by the stake-nets. The catch is emptied as the ebb-tide slackens. In some parts of the East Godavary district, the bag-nets known as *Thadakakattuvala* have bamboo screens one on either side of the net converging from the banks of the creek towards the mouth of the net, to direct the prawns towards the net. Juveniles of *M. monoceros*, *M. brevicornis*, *P. indicus* and *Penaeus monodon* are well represented in the prawn catches of bag nets. In the Gowthami estuary and Upputeru river connected to Collair lake in the Andhra coast, the larger nets 18.3 m long are in use. In the former region the net is operated from anchored boats instead of being tied to fixed stakes. Bamboo poles support the entire length of the head and foot-ropes and help to keep the mouth open and in shape. Heavy stone sinkers are hung from the ends of the pole attached to the foot-rope. Four long ropes tied to the four corners of the mouth of the net are tied to a heavy anchor which is 1.8 m long. ~~(Plate III B).~~ Four short ropes are tied to the ends of the bamboo poles and they are held in the boat. While setting the net, the anchor is dropped first and the boat with the net pulls away from the anchor to the maximum distance possible and when the mooring ropes are tight the net is lowered to the desired depth by paying out the short ropes tied to the bamboo poles. The boat stays with the net hanging from it for the entire duration of fishing. A slack rope is tied to the cod end and held in the boat. Huge quantities of *Leander tenuipes* are caught by this method of fishing from August to November.

The bag-nets employed in the estuaries of West Bengal are known as *Behundijal*, *Behutijal*, *Bhinjal* or *Thorjal* (Kunju 1956 and Pillai and Ghosh 1962). They differ from other bag-nets in having wings extending forwards from the mouth of the net. The bag portion of *Behundijal* ~~(fig. 6)~~ measures 20 m long, mouth 6 m wide and wings 9 m long. Mesh near the mouth is 4.0 cm narrowing to 0.5 cm at the cod end. The mode of operation of the net is similar to the *sus fishing* of Kathiawar coast. The lower end of the extremity of the wing is tied either to a pair of heavy wooden

anchors or to two wooden spikes driven into the mud, while on the upper side a large drum is attached to serve as a float. The mouth is kept open with the help of two bamboo poles each about 5 m long. There is also a buoy at the cod end. In the lower reaches of the Hooghly and Matla rivers prawns (M. brevicornis and L. styliferus) are caught in large quantities during October to March.

Stake nets operated on the West coast:- The stake nets, used in the creeks and tidal inshore areas of the Gulf of Kutch are locally known as Patti. Prawns (M. brevicornis, P. indicus and M. kutchensis) and mullets, polynemids and Sillago constitute the catch during August to December. The nets and its mode of operation has been described by Gokhale (1963). It is made of cotton and is variable in size (12 to 30 m long, 1.5 to 2.5 m high with mesh of 1.0 or 2.0 cm). It is kept stationary with the help of stakes ~~(Fig. 7a and b)~~ placed at regular intervals. No floats or sinkers are used. At ebb tide the net is laid pleated and concealed in the intertidal regions, with the two ends tied to some mangrove trees or poles specially fixed on the land. When the tide is almost full, the fishermen wade through waist deep water, lift the net part by part and fix it on bamboo or mangrove stakes which are carried in their arms. At the turn of the tide all the prawns and other fishes which had entered with the flood tide get caught in the net. Stake nets are also in use in the tidal estuaries of south Gujarat.

Stake nets operated on the east coast:- The 'barrier' nets employed in the Kakinada Bay and backwaters connected to the Godavary estuary are known as Moolakattu vala. They are similar to the stake nets of west coast but longer, extending to over a mile when operated. The net consists of a number of rectangular pieces of cotton netting attached to bamboo poles of 2 m in height and is operated where wide stretches of mud flats are exposed at low tide. A team of about 30 men is required for its operation. The net is carried in 2 or 3 Navas to the mud flats during high tide and just before the turn of the tide the nets are fixed in about 1.6 m of water by pushing the bamboo poles supporting the net into the soft mud and also by treating the lower edge of the net into the mud so that the net forms an effective barrier through which the ebb-tide flows out. The fish and prawns present within the enclosure are effectively

trapped by the small mesh of the netting. They collect in small pools of water left by the receding tide and are scooped up by the fishermen into the boat. Mullets, catfishes, polynemids, sciaenids, white baits and prawns (P. monodon, Penaeus merguiensis and M. brevicornis) are caught. The Char-Pata jal of West Bengal is a similar net (Jones, 1959). In Pulicat lake, Kondavalai, a drag net of coromandel coast, is also used as a stake net to trap prawns. It is fixed upright by a number of sticks in tidal shallows in such a way as to form an imperfect corral trap, one half of the net being in a helicoidal fashion, the other half disposed as a leader to conduct the prawns into a terminal trap (Hornell, 1925). The net is operated at nights.

2. Seine-nets.

These are the typical gears for the bulk fishery along the coast. They include the seines without bags and seines with bags (and wings). They are known as boat-seines or shore-seines depending upon whether they are hauled from a boat or from the beach.

Boat-seines of the west coast:- These are the typical marine fishing gear of the Kerala coast and are one of the most important indigenous gears for the capture of prawns, particularly during August to October when the prawns leave the bottom habitat. They are made of cotton or hemp and are locally known as Paithu vala, Kollivala, Sultan vala, Thanguvala etc. Usually two dug-out canoes with 6-10 men in all are required for this type of fishing. The net may vary in size from region to region. The Kollivala ~~(Fig.8)~~ operated at Kasargod in North Malabar consists of 3 parts - wide-mouthed conical bag 8.5 m long, a platform 11.5 m long and two wings 53 m long, one on either side. The conical bag, made of cotton yarn is made up of 7 sections distally (Vattom) each 0.4 m in height and 8 sections proximally (Melvala) each 0.7 m in height. The Melvala has in addition a 5 layers of 2.5 cm mesh bordering the tip. The platform (Adivala), also of cotton yarn, is about 30 m. at its greatest width and 18 sections each of 0.64 m high constitute this part. Each section in the bag and platform portions, is, in turn, formed by a number of smaller pieces. The cod end section of Vattom has 9 pieces (0.4 m wide) around while the proximal section of Adivala has 60 pieces (0.5 m wide).

The mesh size varies from 1.0 cm at the cod end to 2.0 cm at the platform. The coir wing consists of 5 sections viz. Kachivala (14.5 m long) Kheezhvala (12.2 m) Kanavala(9.5 m) Kadani (9.0 m) and Baikadani (8.0 m). The káchivala is attached to the upper lip of the mouth and it carries floats, whereas the Kheezhvala is joined to the lower lip and has a stone anchor hung from the corner on either side. The mesh size of the coir wings varies from 55.0 cm near the mouth end to 115.0 cm at the warp end. A stout coir rope 18 m long is attached to the free end of each wing. The Sultanvala described by Hornell (1938) is a smaller net, the bag portion measuring only 4.5 long. Both these types of boat-seines are operated in a similar way. The net is carried in two canoes with the bag between them. After reaching the fishing ground, the boats move away from each other in a semicircular fashion, paying out the net. Then they come close and haul up the net after enclosing the shoals in the bag.

In the central zone of the Kerala coast, another type of boat-seine Thanguvala is commonly used for prawn fishing. It is operated either from a single dug-out or two dug-outs with a total complement of 11-13 men. The net is almost rectangular in shape 50-65 m long and 30-40 m at its greatest width and is provided with a long rope at each of its four corners for hauling. There is a wing on either side which is 5-6 m wide. The head rope carries floats and the ground-rope sinkers. Mesh size is about 2.0 cm. Two other types of boat-seines Vattavala and Koruvala, differing mainly in size are also used occasionally in this region. M. dobsoni constitutes the bulk of the prawn catch in the Central and North Kerala coasts.

The boat-seine of the extreme south-west coast (Madivala or Thattumadi) are operated by 2 catamarans or dug-out canoes during April to October. A description of this gear has been made by Nayar (1958). It has a wide mouthed cotton bag (Madi) 10 m long with mesh varying from 0.6 cm at the cod end to 2.0 cm near the mouth. A coir platform is attached to its lower lip. The platform is formed by 3 sections, the central one being 19 m long, 17m wide and mesh 45 cm and two ~~six~~ side pieces 20 x 15.5 m with similar mesh. In front of the platform are two coir wings, one on either side, measuring 27 m long with mesh 270 cm. To the distal extremity of the wings a coir rope 72 m long is attached for hauling the net. The prawn catch consists of P. stylifera and M. monoceros.

Boat seines of the east coast:- The boat-seines constitute an important gear for capture of prawns from the sea on this coast also and they are similar in shape to those of the west coast but with or without wings or platform (Hornell 1925, Jones 1959). They are operated mainly during April-October by a pair of catamarans or in some regions by a Nava and a catamaran. The Thurivalai of the coromandel coast, Iragavala or Oosavala of the Telugu coast ~~(Fig. 9)~~ and Irgali or Irgal jalo (Pedda or Bada Irgali and Sanna or chota Irgali depending on their size) of the Orissa coast are identical in construction and resemble the Kollivala of the west coast except in the absence of a platform. The conical bag is 7-13 m long with mesh varying from 1.0 cm at the cod end to 9.0 cm near the mouth. The wings are 15 to 33 mm long. Floats and sinkers are attached to the head and foot ropes respectively. There is also a stone weight at the cod end.

The Eru valai and Sennakunni valai of the coromandel coast between Madras and Nagapattinam are boat-seines without wings (Hornell 1925). While the Eru valai is a true cone in shape the Sennakunni valai has a deep crescentic notch above so that the floor of the net projects forwards on the lower aspect. These nets have 10/21 floats on the head-rope and no sinkers on the foot-rope. The Sennakunni valai however, has two heavy stone sinkers at the joint between the net and the towing warp.

The Madivalai of the Gulf of Mannar region (Thiagarajan and Thomas 1962) is very similar to the Madivala of the Kerala coast with coir wings and platform.

Compared to the other boat-seines of this coast, the Eruvalai and Sennakunni valai fish only in the upper layer of the water column owing to the presence of a larger number of floats on the head-rope and hence the prawn catch is poor. *M. affinis*, *M. monoceros* and *P. indicus* are the species caught on the east coast.

Shore-seines of the west coast:- These are used mainly for catching inshore pelagic fishes. Prawns (*M. dobsoni*, *M. affinis*, *P. indicus* and *P. stylifera*) are also caught occasionally by these nets. Wall nets of enormous length are used in the Konkan and Kanara coasts and are locally known as Rampan or Rampani (Plate IV-A). The nets, described in detail by

Pradhan (1956) is made of hemp or cotton and consists of a number of pieces varying from 100 to 600 joined end to end. The size of the pieces is variable, 2 to 6 m long and 5 to 11 m high. The pieces towards the free end of the net have a mesh size of 3.0 to 5.0 cm while the pieces forming the middle of the net have a mesh size of 1.2 to 2.0 cm. Wooden floats and sometimes stone sinkers or lead weights are used on the cork-line and lead-line respectively. A long stout rope is attached to the free end of the net on either side for dragging. The net, operated during the post-monsoon months, requires 3 to 5 boats (outrigger type) and 40 to 80 men, depending on the number of pieces used in the net. The rope at one end is held by men on the shore. The net is paid outfrom a boat moving in a semi-circular way, enclosing the shoals. The other end of the net is brought ashore to a point 0.4 to 0.6 km apart from the first and is handed over to another party of men on the shore. The net is then dragged towards the shore. During the monsoon period, a smaller drag net, Yendi or Kairampani ~~(Plate IV-B)~~ consisting of 20 to 30 pieces, each 4 m long and 5 m high is in vogue in the Kanara region. One boat and 8 to 20 men are engaged in this type of fishing. In the estuaries, Kairampani with less number of pieces is operated for catching prawns.

The shore-seine of Kerala coast known as Kambayala or Karamadi (Fig. 10) is a funnel-shaped net with a coir wing and warp on either side (Nayar 1958). The conical net consists of two sections - Aravala 7.5 m and Meluvala 8.2 m in length. The mesh size decreases from 3.0 cm near the mouth to 0.8 cm in the cod end. The wings are of coir webbing and are about 300 m long with a mesh size of 15.0 to 90.0 cm. The warp length is 200 m or more. The net is operated by one dug-out canoe during October-May in a manner similar to the shore-seine of Mysore coast. A smaller type of shore seine without wings known as Nonavala is also in use in the Cochin-Alleppey coast. Small drag nets, called Vadivala, are also used there for prawn fishing during October-February. It is akin to the Kondavalai of the coromandel coast (Hornell 1938) and consists of a length of broad net (width 1.8 - 2.7 m and mesh 2.0 to 5.0 cm) partially doubled upon itself length-wise and laced up at each end to form a long thorough-shaped bag. The mouth is kept open by sticks tied at intervals. Two men drag it ashore in shallow waters keeping the ground-rope at the bottom with the help of the foot. The Korubalae, employed in the estuaries

of North Malabar is also similar to Kondavalai. The net consist of 6 pieces each 1.5 m long and 4.5 m broad with a mesh size of 1.0 cm at the centre and 2.0 cm at the end pieces. On the upper and lower margins of the net there is a 2-3 coir mesh (5.0 cm) layer to which the head and ground-ropes are attached. About 13 sticks of 1 m height each, kept at 0.75 m apart along the length of the net are tied to the head and foot-ropes only so that the net portion is free and forms a bag when dragged against the current. Two men, one on either ends of the net and one im the middle hold the sticks vertically down to the bed and move along for a distance. Then the ends of the net are lifted and the men come close together gathering the sticks quickly such that the catch is collected in the centre of the bag. The operation which lasts for about 5 minutes is repated several times during ebb tide and small quantities of prawns are caught.

In the Saurashtra coast, a simple drag net Bari (5.5 m long, 1.75 m high with 1.0 cm mesh) is used during the monsoon, when it is not possible to go out for fishing. Juvenile fishes and prawns are caught in small quantities. The net is operated in waist deep water by fishermen stretching it between them with a bamboo pole attached to either end of the net. In the inner reaches of the creeks of Kutch the fishermen gather prawns by dragging an open-mouthed gunny bag in less than knee-deep water during August-September (Gokhale 1963).

Shore seines of the east coast:- The Periavalai or Karavalai of the Madras coast described by Hornell (1925) is the shore-seine par excellence of the east coast. It is known as Peddavala in the Andhra coast and Ber jal in the Orissa coast. They are similar to the Karamadi of the Kerala coast except that the wings are in two parts - a proximal 1.5 m long hemp portion and a distal 300 m long coir portion. The funnel-shaped body of the net is 8.5 m long, 18.3 m broad at the mouth and 3.0 m broad at the narrow end. The large detachable truncate cod end is 7.3 m long. The mesh size decreases from 4.5 cm at the mouth to 1.2 cm at the cod end. The wings have 10 cm mesh at the base increasing to 50 cm at the extremities. Hauling rope of nearly a km is attached to the free end of the wings. The head-rope has wooden floats at regular intervals right upto the end of the wing. No sinkers are attached to the foot-rope.

The net is shot in a wide semi-circle from a Masula boat and dragged to the shore by about 12 men at either ends. Prawns (P. monodon and M. monoceros) are occasionally caught in large quantities during February-March along the Andhra and Orissa coasts when they are believed to be driven close to the shore as a result of upwelling.

The Alivivala or Ayil (also known as Pedda alivi and Chinna alivi according to size) is a well net akin to Rampani of the west coast, having a limited distribution between Pentakota and Kakinada of Andhra coast. It consists of a central portion with 3 to 6 rectangular pieces made of cotton (each piece 7.0 to 10.0 m high and 4 m wide) and a long tapering wing with 20 to 33 sections of cotton netting on either side. The length of each section is 18 m and the height decreases gradually towards the free and when it is only 1.1 m. At the free end of the wing is a stout bamboo pole of 0.55 m height to which is attached a thick hauling rope. At intervals of 3 m, irregularly-shaped wooden floats and stone sinkers are attached to the entire length of the head and foot-ropes respectively. Five large wooden buoys, one on central section and 2 each on the wings are attached to the head-rope to indicate the position of the net. The mesh size varies from 1.2 cm in the centre pieces to 4.0 cm at the extremity of the wings. The net is cast from a nava and hauled up by 12 to 30 men (depending on the size of the net) at each end. The Chinna alivi is operated throughout the year while the Pedda alivi is used only during November-March. As the central section comesnear the shore any escaping fish or prawn is caught by konti valas (vide infra) operated just outside the Alivi. The high central section folds upon itself as the net is dragged to the shore and forms an effective bag. The prawn catch of these nets is better compared to the Peddavala and comprises of M. brevicornis, M. affinis, M. dobsoni, M. monoceros, P. merguiensis, Acetes spp. and P. tenuipes.

Among the drag nets employed in the backwaters, Kondavalai of the Coromandel coast described by Hornell (1925) has its counter parts all along the east coast. They are called as Konti vala or Eedupu vala in the Telugu coast, Khadi jal in Chilka lake and Hata jal in West Bengal. Essentially the net consists of a long broad strip of netting having the upper and lower margins connected and supported by spreader sticks which

are invariably shorter than the width of the strip of netting. Distance between spreader sticks is about 0.6 m. The larger nets may be 18.3 m or more in length with 30-40 spreader sticks 0.7 to 2.75 m. The smaller nets are about 3.66 to 4.55 m long with a depth of bag of 1.5 to 1.8 m the number of spreader sticks is usually seven, 0.6 to 0.7 m in height. The webbing is of cotton-twine and the meshes are extremely small varying from 0.6 to 1.3 cm. The net is dragged by 2 men wading in the shallow regions and prawns constitute a good portion of the catch. In the Pulicat lake a group of 8 to 10 nets may be operated in a gradually narrowing circle. Another type of drag net known as Pakkadevu vala is very popular in the creeks of Godavary delta. It is 7.9 to 9.1 m long, width increasing from 5.9 m at one end to 10.4 m at the other. The mesh decreases from 3.0 cm at the broad end to 1.2 cm at the narrow end. The net is operated in conjunction with a small nava with a crew of two men. The narrow end of the net is secured to the gunwale of the boat and the sides of the net are tied to bamboo poles 3.66 m high, fixed at the bow and stem of the boat. Two short bamboo sticks 0.55 m. high, are attached to the corners of the broad end of the net which is dragged along with the boat to the shore by two men (boat crew) wading in waist-deep water (Plate V). At the ~~sea~~ shore, the dragged end is lifted up and the catch is manipulated to fall into the boat. The operation which lasts about 10-15 minutes is repeated a number of times. Prawns (juveniles of *M. monoceros*, *P. indicus*, *P. monodon* and *Macrobrachium* spp.) form the bulk of the catch.

3. Cast-nets or Falling nets

These are primitive devices, limited in their efficacy.

Cast nets of the west coast:- This is a very common and primitive gear used all along the coast and is known as Chogiya, Pag, Beesubale, Vichuvala etc. in different regions. It is made of cotton or nylon and is conical in shape, the margins having lead weights. There are two varieties, stringed and stringless. ~~(Fig. 11 a and b).~~ In both there is a central line which is held by the hand for hauling the net. In the case of the stringed variety, the central line branches out into several strings before reaching the margin of the net, so that pockets are formed at the

margin and are pulled together as the net is hauled up. In the other variety, the pockets are fixed by turning over the lower rim and fastening it by twines. There is no connection between the central line and these pockets. The size of the net varies from 2.5 to 6.0 m in radius with 1.0 or 2.0 cm mesh. It is hand operated from the shore or from a small boat carrying 2 to 8 men when shoals come very near to the shore. The net is cast with a swinging movement, fully spread. The circumference of the net closes as the lead line sinks fast trapping all the fishes and prawns in the water column below the net. In the Kanara and Kerala coasts during the rainy season of July-September cast net boats operate in concentrations in areas where shoals are sighted near the surface ~~(Plate-VI A)~~ M. dobsoni is caught in good quantities at this time. ~~(Plate-VI-B).~~ This net is also employed for fishing in creeks and backwaters.

Cast nets of the east coast:- The cast nets (known as Veechu valai, Vessura vala or Kepla jal) are used in the creeks and estuaries all along the east coast. Prawns (species of Macrobrachium, Metapenaeus and Penaeus) are caught in small quantities by this gear.

4. Scoop-nets or Skimming-nets

These are employed exclusively in the backwaters, creeks and estuaries. They comprise of the hand-net, push-net and lift-net.

Scoop-nets or skimming-nets of the West coast:- The hand-net (Arippu vala or Vattu vala) is a small bag-shaped net of 0.6 - 1.2 cm mesh with or without handle and is used in the Kerala and Kanara coasts to dip out prawns and small fishes (Hornell, 1938). This bamboo or cane bent into an ovate shape forms the mouth of the net. ~~(Fig. 12).~~ The lift nets or the chinese dip-nets (Cheena vala or Kambu vala ~~(Plate-VII-A)~~ described by Hornell (1938) are large and are extensively used in the backwaters of Cochin and Azhikode in Kerala. A typical net is of 9-10 m square with a mesh of 0.2 cm at the cod end increasing to 5.0 cm at the mouth. The mouth is kept distended by two bamboos each about 2 m or more in length crossing each other at mid lengths ~~which are~~ and lashed together at right angles. Their distal extremities are attached to the four corners of the mouth of the net. The net is alternately lowered into the water

and raised with the help of a complicated, balanced movable framework. Two men are required to operate this net. Sometimes a light is hung from the apex of the frame to attract fish and prawns during night fishing. Juvaniles of M. dobsoni, M. monoceros and P. indicus comprise the prawn catch.

Scoop-nets or skimming nets of the East coast:- The push nets of the east coast are similar to the hand nets of the west coast but are large. They have to be pushed and hence known as push nets. They are characteristic of the creeks and estuaries of Andhra, where they are called Dhobbudu vala or Pakkadevudu vala. The net is about 1.8 m long with a triangular mouth and truncate cod end. The mouth of the net is supoorted by a triangular frame whose base is formed of a 1.2 meters long flat wooden plank and the sides (1.4 m long) are formed by two bamboo poles crossing each other at the apex of the net. The portion of the bamboo poles projecting above the apex of the net forms the handle (about 0.5 m long) for pushing the net. The net, made of cotton, is in three sections. The first piece is more or less a square when first fabricated. Three sides of this square are attached to the triangular frame while the fourth side is folded and sewn up to half the distance from the apex of the triangle. The lower unsewn half now forms a circular opening to which is attached a cylindrical net 0.5 m long. To the posterior end of this cylindrical piece is attached the 28 cm long truncate cod end which is 50 cm wide anteriorly and 88 cm wide posteriorly. The mesh size diminishes from 1.0 cm near the mouth to 0.7 cm at the cod end. The net is pushed in front by a man wading through shallow regions and small quantities of prawns (juveniles of Metapenaeus) are caught. A smaller net with a uniform mesh-size of 0.7 cm is used in the Kakinada Bay and creeks for catching Acetes spp.

In the Kakinada Bay and tidal creeks of the Godavary estuary rectangular dip nets known as Yettudu Dimpudu, akin to the Kambuvala of the west coast, are operated during the post-monsoon period. The net is 14.2 m long, breadth being unequal 76.9 m at the dipped end and 13.3 m at the opposite end. It is made of cotton and mounted on thick jute ropes. The mesh size decreases from 6 cm near the wide end of the net to 2.0 cm at the narrow end.

The net is fixed in tidal areas with the help of poles and coir ropes and when not in use, looks like a sagging canopy over the water. Usually a shoe-thoni with 4 men is used to operate the net. But sometimes more than one may be found near the net, assisting the operators. The boat is positioned behind the narrow end of the net and the rope on which the net is mounted is held above the surface of the water by two men in the boat. On a triangular wooden platform erected near each corner of the wide end of the net, stands a man holding a 2.5 m long stick, one end of which is tied to the corner of the net. During the incoming tide the two men standing on the platform dip the end of the stick to which the net is tied, right up to the bottom of the creek and thus hold the wide end of the net under the water. Now the net forms a shallow bag through which the tide flows. Every two or three minutes the front end of the net is lifted up far above the head of the men on the platform and the catch pushed to the narrower end of the net from where the men in the boat remove the catch with the help of small hand-nets, sometimes wide-meshed screens made of cotton-twine are fixed in a diverging manner from the triangular platforms to the banks of the creek to direct the fish towards the mouth of the net. The net is operated during night or daytime but usually when the flow of the tide is strong. Prawn catches are said to be good during night-time when they may form about 50-70% of the catch. Juveniles of P. indicus, M. dobsoni, M. brevicornis and M. monoceros are generally caught in this net.

5. Drift-nets

These are passive fishing net walls of selective nature.

Drift-nets of the West coast:- These are gill-nets made of cotton, hemp or nylon. In the Kanara and North Malabar coasts big-sized prawns (P. merguiensis, P. indicus ~~an~~ M. affinis etc.) are caught in small quantities in the bottom-drift nets (Kanthabala or Kanthavala) which are operated by 2-3 men in a dug-out during November-April mainly for catching mackerel, sharks, catfishes, crabs etc. The net consists of 16-25 pieces, each 3-5 m long, 2-3 m high with mesh size of 5 to 6 cm. It is set in position with stone sinkers on the foot-rope and floats on the head-rope, allowed to dirft with the current for sometime and then lifted

to collect the catch. In the south-west coast, surface drift nets known as Vala valai or Pattuvala (40 to 50 pieces each of 5.4 x 1.8 m with mesh size of 3.0 cm) are operated by two men on a catamaran for catching *Chirocentrus* and prawns (*P. indicus*).

Drift-nets of the East coast:- The Kilevalai of the Telegu coast is similar to the Kanthavala of west coast. It is operated by 4 to 6 men on a Nava almost throughout the year. Large-sized prawns (*P. monodon*, *P. merguiensis*, *P. indicus*, *M. affinis* and *M. brevicornis*) are caught in small quantities.

6. Traps

These are of various designs, from the simple basket trap to the complicated weirs or pound weirs which are exclusively used in the estuaries and backwaters.

Traps of the west coast:- Simple devices known as ottals are in vogue in Kerala (Hornell 1938). They are the basket traps or cover pots used in shallow waters rich in plant growth as well as in the paddy fields. They are sub-conical in form ~~(Fig. 14)~~, 0.5 - 0.6 m high, open at both the ends, the upper one being narrow. They are made of bamboo splints, looped at invervals with split cane or coir cord. The lower end is armed with spikes by sharpening the split ribs to a point. The basket is plunged into the water every few steps, passing the lower end into the mud with one hand and removing the fish and prawns inside the trap with the other, through the opening at the top.

The screen barriers (Thattuvala) described by Hornell (1938) are somewhat complicated. They consist of several screens (thatties) arranged as vertical walls supported by strong poles driven into the mud. There are circular, heart-shaped or rectangular trap chambers set at intervals. The traps are also made of vertical screens. The screens are formed of narrow strips of bamboo 1.5 - 1.8 m high, laced together with coconut twine transversely about 0.3 m apart. The screen barriers are used in the shallow and tidal backwaters of Malabar. As the tide recedes, the fishes caught within the area are forced to pass into the trap chambers.

Traps of the East coast:- A variety of trapping devices are used on the east coast. In the Chilka lake prawns are caught almost exclusively by bamboo traps which are akin to the bamboo screen traps operated in the estuarine ponds of Philippines. Two types of traps Daudi and Cheengri Baaza are in use. Their description and mode of operation have been dealt with by Job and Pantulu (1953) and Jones and Sujansinghani (1954). Daudi is a prism-shaped and is made of bamboo strips of about 0.6 cm width. Usually strips of 34 bamboo poles each 1.05 m long are required to make one Daudi which measures 1.5 x 0.3 x 1.0 m. Cheengri Baaza is a rectangular trap made of three parts namely Patta or strap 2.2 x 0.55 m forming the four sides and two rectangular pieces each 0.8 x 0.2 m forming the top and bottom. Both the kinds of traps are used in conjunction with bamboo screens known as Thatta measuring 12 x 1.2 m. The fishermen construct fences with such screens extending from the shore into the lake to a length of 180 to 275 m and a ring of traps 7 to 8 is placed around the lake end of the fence in waters of 1.0 to 1.5 m depth. The baaza type traps are placed at the three corners of the triangular enclosure formed of bamboo screens at the lake end. The traps are set in the evening. Prawns which move along the shore at the night are guided by the screens into the traps. Fishing is carried out almost throughout the year and good quantities of prawns (juveniles of P. indicus and P. monodon) are caught.

In the deltaic areas of Godavary and Krishna, Bamboo basket traps called Movu of the hut-box type described by Job and Pantulu (1953) are operated in the irrigation channels connected to the backwaters during July-October. The trap made of bamboo splints has a rectangular base and the basket is also more or less rectangular in shape up to the middle; above, the bamboo splints converge to a straight line at the top running the length of the trap, leaving a small hole at one end, to empty the catch. The size of the traps is variable. A medium-sized trap measures 1.0 x 0.15 m at the base and 0.7 m high. There is an opening guarded by bamboo splints near the bottom on each of the two broader sides. In the larger traps there are two openings on each side. The traps are set across the canals during July-October, either single or in rows depending upon the widths of the canal. Macrobrachium spp., M. monoceros and P. monodon are caught by these traps. In the swamps of Collair lake and

Upputeru river, telescopic two-piece conical bamboo basket cage or traps called Gampa garre and rectangular bamboo basket cage or traps called Mayulu are extensively used in batteries for the capture of prawns (Venkataraman et al. 1956).

7. Miscellaneous devices

These include Pachil of the Kerala brackishwater lakes and the pouch trap net of Pulicat Lake.

Miscellaneous fishing devices of the West coast:- In the shallow stretches of the brackish water lakes and canals of Kerala, an interesting method under the name Pran-junkhar or Pachil (Gopinath, 1953) is adopted for catching prawns. In this method, a long heavy iron chain attached to the bows of two canoes which are braced together by cross bars is dragged along the bottom. The chain disturbs the prawns living close to the bottom which jump out of water and fall into the canoe where they are trapped by means of a criss-cross arrangement of bushes or coconut bracts.

Miscellaneous fishing devices of the East coast:- The same principle of dislodging prawns from the bottom is followed in operating the Kalvalai, a pouch trap of the Pulicat Lake. It is a huge bowl-like net made of cotton (Hornell 1925), 18.3 m in circumference and 5.5 m deep with a narrow-mouthed bag or cod end and mesh size of 2.5 cm. Two long stout coir ropes weighted with small stones at short intervals are attached to the extremity of mouth one at each end. The net is operated in the deeper stretches of the backwaters. The lower edge of the mouth is firmly fixed to the ground by stakes and the upper edge is held up by two men to keep the mouth open. The two stone laden ropes are paid out by two men so as to diverge widely in front of the mouth. Holding the rope end they cross over ~~the~~ to the other side, gradually reducing the area enclosed by the two lines. The moving ropes dislodge the prawns and flatfishes from the bottom and drive them towards the mouth of the net. As the ropes come close to the mouth, the foot-rope is set free and lifted up, thus closing the net.

8. Trawl nets

These are modern contraptions to capture prawns near the sea bed.

The marine prawn fishery in India, employing indigenous gears was largely seasonal. However, its value as a dollar earner has provided the impetus for improving the conventional gears to catch prawns in the off-seasons and explore new grounds. As a result, trawl fishing has developed.

Beam trawling is not done anywhere in India as it imposes certain limit on the length of the beam (maximum 12 m) and consequently on the horizontal opening of the net and the area that could be fished. The most developed method for keeping the towed net open horizontally to the maximum extent is the use of long wings and otter boards. Otter trawling has been found to be very successful for the exploitation of demersal fisheries and is therefore resorted to, on a commercial scale on both the coasts of India. It is operated from a mechanised boat with a crew of 3-6 men. In some parts as in Kerala and Kanara coasts it is also operated from a dug-out, close to the shore by two men. The canoes are anchored heavily with a long rope. After rowing the boat away from the anchor to the maximum distance, the trawl net is cast. It is then towed by moving the boat to the original position, holding the anchor rope. The net is then hauled up. Each operation lasts for about 10 minutes.

The otter trawl ~~(Fig. 45)~~ incorporates the features of several of the indigenous devices such as the winged bag and seine nets and Pachil. The design of some of the shrimp trawls is given by Satyanarayana and Nair (1962) and Kuriyan et al. (1964). The otter boards are shaped in such a way that maximum shearing power and least resistance to towing are obtained. Their size and weight vary from 0.75 x 0.4 to 1.4 x 0.9 m and 11 to 90 kg respectively, depending upon the dimensions of the net and the towing power required. Two or four seam trawl nets, overhang or non-overhang type, with a head line length of 7-27 m between the upper wing ends, are operated. Barrel-shaped thermocole floats or spherical aluminium floats are attached to the head-rope. The foot-rope is longer than the head-rope and varies from 8 to 35 m. It carries spindle-shaped lead sinkers. The mesh size of the net is variable from 5 to 10 cm at the

cod end. The trawling speed ranges from 1.5 to 4.5 knots/hr according to the size of the gear and horse power of the boat. Fewer floats on the head-rope, a heavier ground-rope with a thin tickler chain attached ahead of it and comparatively long wings would seem to make this gear more effective for catching prawns (Kuriyan <u>et al</u> 1962 and Deshpande and Kartha 1964).

Considering the different types of gears used for prawn fishing, it is seen that apart from otter trawl, boat-seines of variable design constitute the most important gear for capture of prawns from the sea on both the coasts of India. In addition, bag nets and stake nets are of importance on the north-west coast where the tidal flow is strong. In the Kanara and Kerala coasts cast nets and shore-seines are employed for catching prawns close to the shore. The latter gear is also important in parts of Andhra coast. Compared to the marine fishing gears, a greater variety of devices is in vogue for prawn fishing in the estuaries, backwaters and creeks. In the tidal regions of the east and west coasts bag nets are operated, besides stake nets. Various kinds of drag-nets, scoop-nets and traps are the other gears used in the backwaters.

Although trawl fishing accounts for the bulk of the prawn catch from the sea, its operation is still mostly confined to the inshore waters of 15 to 30 km range from the shore. It would be necessary to extend them into the offshore regions with suitable trawlers to explore the possibility of stepping up our valuable resources. The results of the recent exploratory operations between 300-400 m depth off the south-west coast of India are encouraging in this direction.

X CRUSTACEAN PRODUCTION IN INDIA

By

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X. CRUSTACEAN PRODUCTION IN INDIA

S.K. Banerji

The crustaceans form a very important fishery in India. The average production of marine crustaceans based on the 10 years data from 1959 to 1968 was estimated at 84,734 tonnes and forms about 10.89% of the annual production of all fish, estimated at 777,733 tonnes. The above estimate of crustacean landings does not include the production generated from the backwaters, paddy fields, lakes and estuaries. Although no reliable estimates of production from these sources are available, rough estimates of production from these sources are available. These estimates place the production from these sources at more than 50% of the marine production. The production of marine crustaceans from all sources in India would thus form more than 10% of the world production of crustaceans which in 1967 was estimated at 1350,000 tonnes. Thus the total crustacean~~s~~ landing not only form a sizable part of the total marine fish landings in India but it accounts for more than 10% of the world crustaceans production. This will indicate the importance of the crustacean~~s~~ fishery in India. If the increasing demand for prawns from U.S.A. and other foreign countries is remembered, the importance of the Indian crustacean fishery will be understood better because out of an average annual production of 84,734 tonnes of crustaceans as much as 81,699 tonnes on an average consist of prawns. The prawn production in India forms about ~~15~~ 13% of the total world production of prawns and shrimps which ~~is~~ in 1967 was estimated at 690,000 tonnes. If the substantial production from backwaters paddy fields, lakes and estuaries etc., are also taken into consideration, the percentage of Indian production to the world production of marine prawns will be about ~~20~~ 18%.

The table I presents the production of marine crustaceans in India together with its composition into 3 broad groups from 1959 to 1968. It may be seen from the bottom row of the table, that pennaeid prawns with an average annual production of 47,538 tonnes form 56.10% of the average annual crustacean production in India. The next group in importance is the non-penaeid prawns whose average annual production is 34,161 tonnes

forming 40.32% of the average annual crustacean production. The two groups of prawns together form 96.42% of the average annual crustacean production, the balance 3.58% consisting of other crustaceans with an average annual production of 3,035 tonnes. It will be seen from the table I that for the country as a whole, the annual landings of penaeid prawns increased from 27,632 tonnes in 1959 to 63,389 tonnes in 1964; showed some decline in 1965 and again increased to 68,102 tonnes in 1968. Apart from minor fluctuations in a few years, the data show a definite rising trend for the annual landings of penaeid prawns. To find out the trend, a quadratic equation of the type $y = a + bt + ct^2$ (where y is the annual production in thousand tonnes, and t is the year, the base year 1959 being taken as t=0) was fitted to the data by the method of least squares. The fitted equation was

$$y = 29.6278 + 4.0913t - 0.0189t^2$$

The figure 51A shows the fitted equation to the observed data. It is pertinent to examine if the deviations from the fitted data are due to random fluctuations around the trend or there is some serial correlation. This was tested by Von Neuman's ratio given by $\Sigma \frac{\Delta u_i}{u_i 2}$ where $\Delta u_j = u_i - u_{i+1}$ and $u_i = \hat{y}_i - y_i$. It was seen that the fluctuations round the trend were random, and the fitted equation will best represent the trend in the annual production. The high positive b value indicated the rate of increase per year and negative c value indicated the rate at which the above rate is being retarded.

By fitting a similar regression to the annual production of non-penaeid prawns, we get the following equation

$$y = 34.0462 + 0.7518t - 0.1098t^2$$

From the figure 51B, it will be seen that there is very little indication of trend in the annual production of non-penaeid prawns. The fluctuations are found to be random in nature.

The trend in the annual production of other crustaceans is shown in figure 52A and is represented by the equation

$$y = 19.7367 + 0.1384t + 0.3523t^2$$

where y is now expressed in units of 100 tonnes. From the trend it is

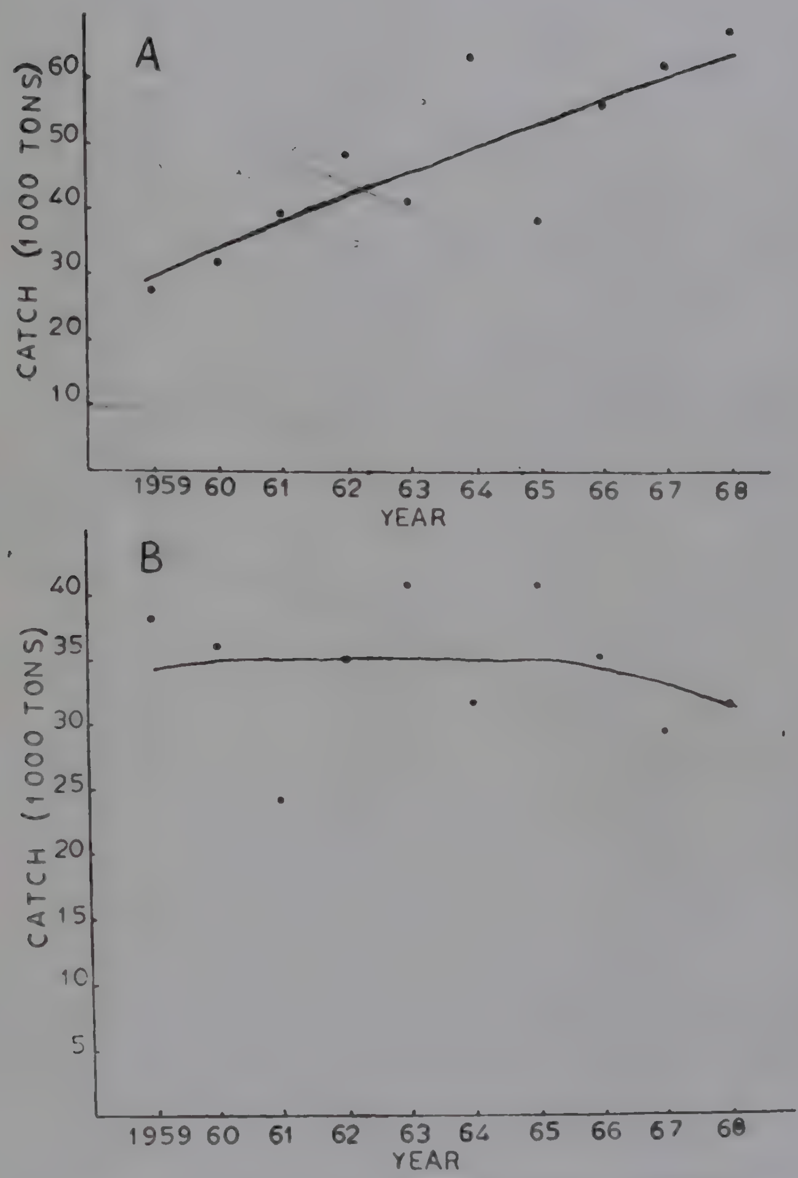

Fig. 51A. Trend $Y = 29.6278 + 4.0913t - 0.0189t^2$ in the annual production of penaeid prawns in India.

B. Trend $Y = 34.0462 + 0.7518t - 0.01098t^2$ in the annual production of non-penaeid prawns in India.

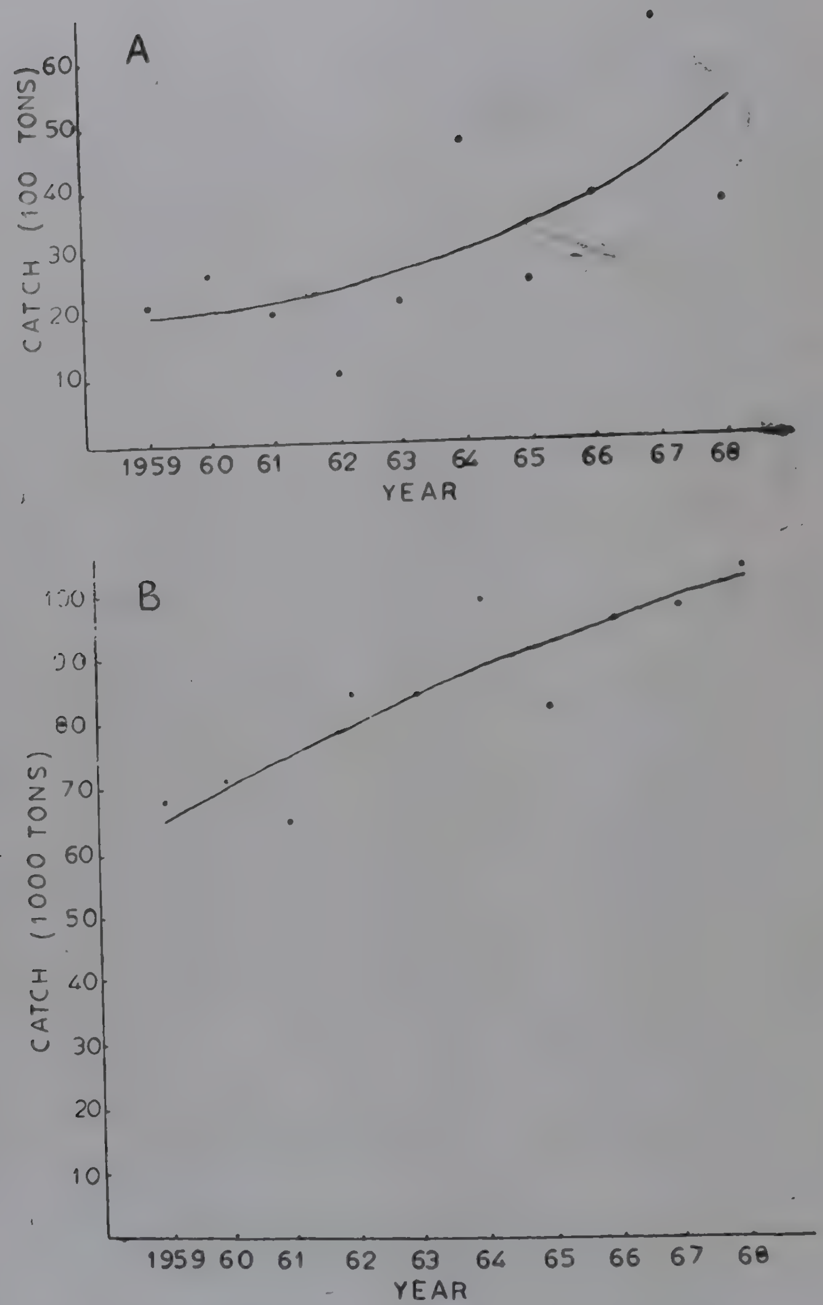

Fig. 52A. Trend $Y=19.7367+0.1304t+0.3523t^2$ in the annual production of other crustaceans in India.

B. Trend $Y=65.6357+4.9307t-0.1061t^2$ in the annual production of all crustaceans in India.

seen that annual production dropped till 1961 from whence an upward trend is noticed. Von Neuman's ratio test showed that the deviations of actual observations from the trend line were of random nature and as such the fitted equation will best represent the trend in the annual production of other crustaceans in India.

The figure 52B shows the trend in the annual production of all crustaceans in India. The equation of the trend is given by

$$y = 65.6357 + 4.9307t - 0.1061t^2$$

The trend is similar to the one found in case of the annual production of penaeid prawns.

State-wise break up of annual landings

Crustaceans are landed in all the maritime States of India but the amount of landings differ from state to state. The table II shows the State-wise landings of crustaceans from 1959 to 1968 together with the average annual landings in each State and the percentage contribution of each State. It will be seen that the landings on the east coast of India form only about 16.45% of the total crustaceans landings, while the balance of 83.55% is landed on the west coast of India. Among the States, Maharashtra ranks first by contributing 47.82% of the total crustacean landings in India, followed by Kerala which contributes on an average 27.25% of the average annual production of crustaceans. The percentage contribution of other States are small and may be seen from the last column of table II. In fact the major crustacean fishery of India are today located in the two States of Maharashtra and Kerala.. Hence, it will be only proper to examine the trend of crustacean landings in these two States.

Crustacean fishery in Maharashtra

The tables III to V show the State-wise landings of penaeid prawns, non-penaeid prawns and other crustaceans from 1959 to 1968. From these tables, it will be seen that the composition of the average annual crustacean production of 40,517 tonnes in Maharashtra may be broken up as follows.

	Tonnes	Percentage
Penaeid prawns	8,969	22.13
Non-penaeid prawns	31,509	77.77
Other crustaceans	39	0.10
Total	40,517	100.00

Thus, in Maharashtra, penaeid prawns which are very important from the point of view of export earnings form only 22.13% of the total crustaceans landed in the State. The major portion of the crustaceans landings in the State consists of small non-penaeid prawns.

From table III, it will be seen that the landings of penaeid prawns in the State was only 5,746 tonnes in 1959, varied from 8 to 9 thousand tonnes during the next years, dropped down to the minimum of 5,032 tonnes in 1963, touched the maximum of 14,301 tonnes in 1964 and varied between 8 to 11 thousand tonnes during the next 3 years. Fitting a second degree quadratic equation to the annual landings of penaeid prawns expressed in thousand tonnes, we get the equation

$$y = 6.6371 + 0.7904t - 0.0454t^2$$

If this represents the trend in the penaeid prawn landings, it will be seen from figure 53A that the production shows an increasing trend upto 1964 and thereafter there is a slow decline. The fluctuations around the trend line are again seen to be random and therefore the fitted line may be considerated to represent the trend best.

The landings of non-penaeid prawns in Maharashtra also showed fluctuations from 21,744 tonnes in 1961 to 37,482 tonnes in 1963. The fitted trend line is given by the equation

$$y = 26.3900 + 3.0089t - 0.2993t^2$$

where y is expressed in 1000 tonnes. The figure 53B shows the fitted lines along with the actual landings in different years. The trend showed increase up to 1965 showing slow decline thereafter.

As there is no significant landings of other crustaceans in Maharashtra, it is not necessary to fit any trend line to the data.

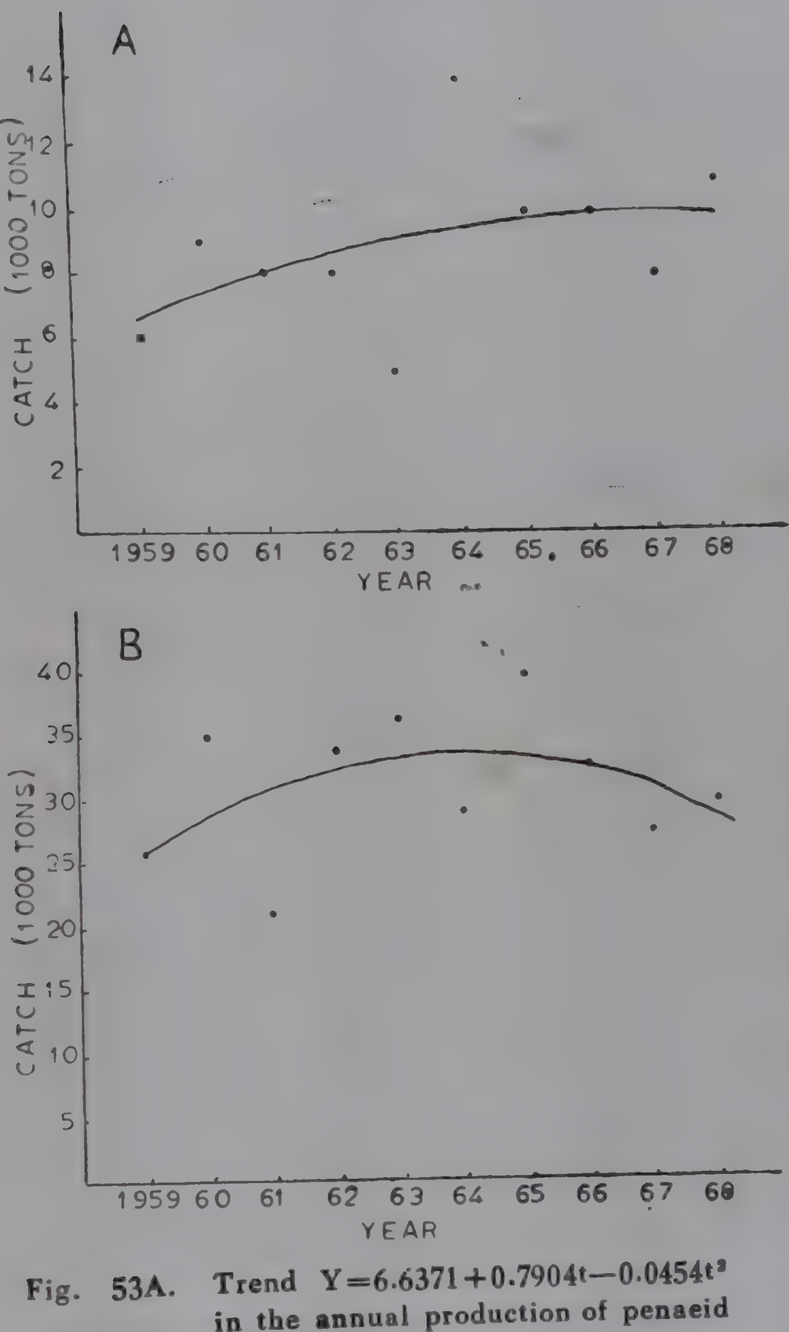

Fig. 53A. Trend $Y=6.6371+0.7904t-0.0454t^2$ in the annual production of penaeid prawns in Maharashtra

B. Trend $Y=26.3900+3.0089t-0.2993t^2$ in the annual production of non-penaeid prawns in Maharashtra.

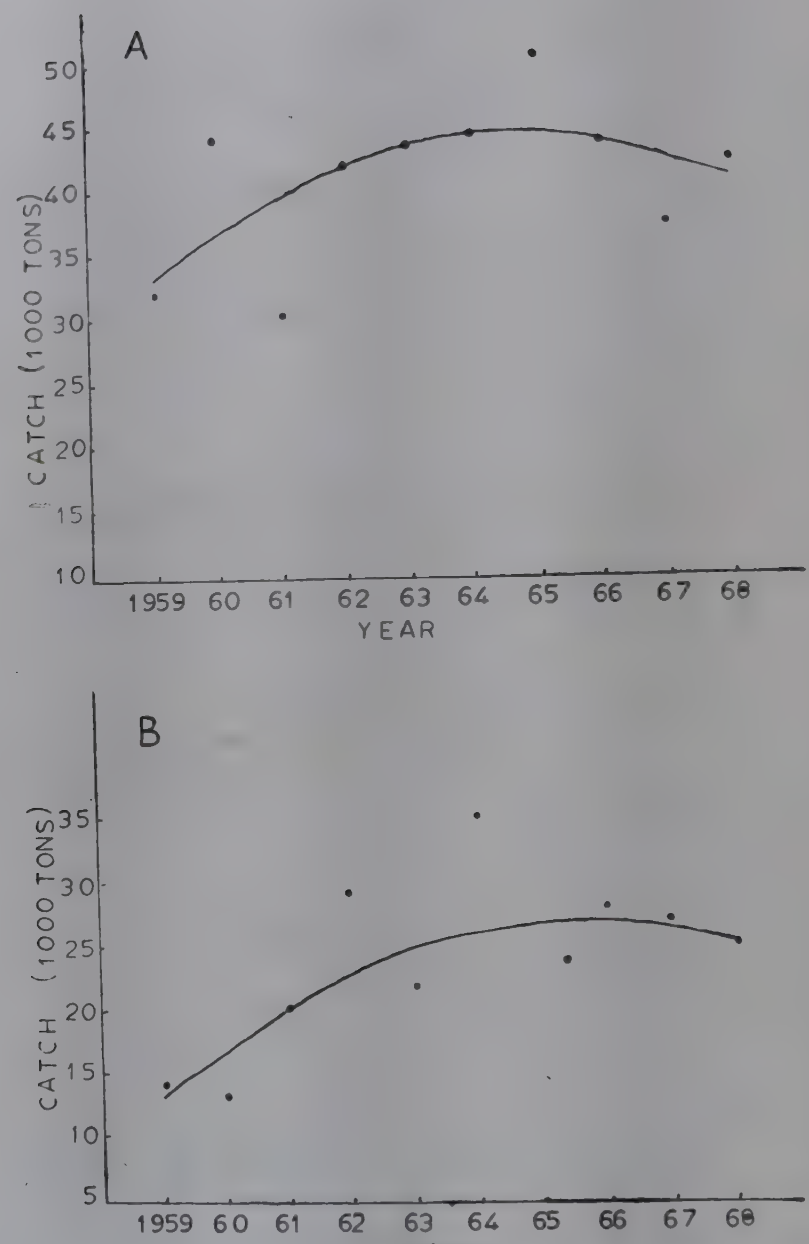

Fig. 54A. Trend $Y = 32.9923 + 3.8953t - 0.3446t^2$ in the annual production of all crustaceans in Maharashtra.

B. Trend $Y = 12.9728 + 4.3447t - 0.3447t^3$ in the annual production of penaeid prawns in Kerala.

For the total crustacean landings, the trend is given by

$$y = 32.9923 + 3.8953t - 0.3446t^2$$

where y is in units of 1000 tonnes. The trend was increasing up to 1965 and then it showed a slow decline (Fig. 54A).

Crustacean fisheries in Kerala

The composition of the average annual production of crustaceans is as follows.

	Tonnes	Percentage
Penaeid prawns	22,828	98.87
Non-penaeid prawns	111	0.48
Other Crustaceans	150	0.65
Total	23,089	100.00

The most remarkable feature of crustaceans landings in Kerala is that 98.87% of the same consists of valuable penaeid prawns. A second degree equation fitted to the data on the annual landings of the penaeid prawns is as follows.

$$y = 12.9728 + 4.3447t - 0.3447t^2$$

The fitted line together with the actual annual landings are shown in figure 54B. It will be seen that there was a rising trend in the annual landings of penaeid prawns up to 1965 and thereafter the trend shows a slow decline.

The landings of non-penaeid prawns and other crustaceans in Kerala are so small that no attempts are made to fit trend lines to them.

Species composition of crustacean landings and distribution

It has been stated that the crustacean catch of India can be divided into 3 broad categories viz., (1) the penaeid prawns, (2) the non-penaeid prawns and (3) other crustaceans. The average annual catch of each category together with its percentage contribution may be seen from table I. The penaeid prawns are relatively large sized and are valuable

for export earnings. They are represented in the catch by a number of species but from the point of quantity landed all of them are not equally important nor are they distributed all along the coast line. The table VI presents the State-wise species composition of average annual penaeid prawns landings. The average annual landings of each species in the whole country are also shown. These figures have been worked out from the data available in the Fishery Survey Division of Central Marine Fisheries Research Institute.

It will be seen that among the penaeid prawns *Metapenaeus dobsoni* tops the list with an average annual landings of 16,072 tonnes forming 33.81% of the penaeid prawn landings and 18.97% of the crustacean landings in India. The species was landed in small quantities all along the east coast and also along the west coast south of Maharashtra. The major portion of the landings was in Kerala. Next in order landings was *Parapenaeopsis stylifera* with an average annual landings of 8,163 tonnes, forming 17.17% of the penaeid prawn landings and 9.63% of the crustacean landings, in India. The species was landed only along the west coast, the major landings being in Kerala and Maharashtra. *Penaeus indicus* with an average landings of 5,552 tonnes formed 11.68% of the penaeid landings and 6.55% of the crustaceans landings in India. It was landed all along the east coast and in Kerala and Mysore in the west coast. More than 91% of the landings came from Madras and Kerala.

Metapenaeus affinis accounted for 4,590 tonnes of landings forming 9.66% of penaeid prawn and 5.42% of crustacean landings in India. The species was landed all along the east and west coast though about 72% of the landings came from Maharashtra and Gujarat. Next in importance was *M. brevicornis* with an average landings of 3,273 tonnes and forming 6.89% of penaeid prawn and 3.86% of total crustacean landings in India. The species was landed mainly in West Bengal, Orissa, Andhra but small quantities were also landed in Maharashtra and Gujarat.

The other notable species in order of their landings were

	Landings (tonnes)	Percentage to penaeid prawn landings	Percentage to total crustaceans landings
M. monoceros	2,093	4.40	2.47
Parapenaeopsis hardwickii	1,720	3.62	2.03
Penaeus monodon	1,321	2.78	1.56
Parapenaeopsis sculptis	1,199	2.52	1.42
Solenocera indicus	638	1.34	0.75
Penaeus merguensis	637	1.34	0.75

Metapenaeus monoceros was landed in all the marimime States of India, though their landings in Kerala and Mysore were very small. Parapenaeopsis hardwickii and P. sculptilis and Solenocera indicus were obtained only in Maharashtra and Gujarat. Penaeus monodon, were landed all along the east coast and also in Kerala on the west coast. Penaeus merguensis was landed mainly in West Bengal, Orissa and Andhra. Besides the above, other species like P. semisulcatus, P. penicillatus, Parapenaeopsis uncta etc. also contributed small quantities towards the penaeid prawn landings.

The species composition of non-penaeid prawns and other crustaceans are shown in tables VII and VIII. Among non-penaeid prawns the most important in order of landings are as follows:-

	Landings (tonnes)	Percentage of non-penaeid prawns	Landings of total crustaceans
Acetes indicus	13,514	39.56	15.75
Palaemon tenuipes	6,111	17.89	7.21
Palaemon styliferus	3,936	11.52	4.65
Hippolysmata ensirostris	2,397	7.02	2.83

Acetes indicus was landed in Ahdhra, Madras, Kerala and Maharashtra but more than 97% of landings was in Maharashtra. Both the species of Palaemon were landed in good quantities in Maharashtra and Gujarat. Similarly Hippolysmata ensirostris was landed only in Maharashtra and Gujarat.

Among other crustaceans, crabs belonging to the genera Neptunus and Scylla formed respectively 88.16% and 4.00% of the landings of other crustaceans. Neptunus landings were obtained all along the coast, though the bulk came from Andhra and Madras. The main landings of Scylla were at Madras. Lobster belonging to genus Panulirus was mainly landed in the south west coast of Madras and in Kerala.

TABLE I

Prawn and crustacean landings in India from 1959 to 1968

Year	Landings in tonnes of Penaeid prawns	Landings in tonnes of Non-penaeid prawns	Other crustacea	Total crustacea	All fish	P.C. of crustacean to all fish
1959	27,632	37,805	2, 093	67,530	584,587	11.55
1960	31,759	36,271	2,571	70,601	879,681	8.03
1961	39,083	23,685	2,038	64,806	683,569	9.48
1962	48,251	34,984	1,031	84,266	644,244	13.08
1963	41,071	40,522	2,061	83,654	655,484	12.76
1964	63,389	31,506	4,565	99,460	859,582	11.57
1965	38,085	41,415	2,392	81,892	832,772	9.83
1966	56,146	34,768	3,716	94,630	889,651	10.64
1967	61,865	29,064	6,291	97,220	850,171	11.44
1968	68,102	31,586	3,595	103,283	897,587	11.51
Average	47,538	34,161	3,035	84,734	777,733	10.89
p.c.	56.10	40.32	3.58	100.00		

TABLE II

Statewise landings of all crustaceans from 1959 to 1968

States	Landings in tonnes										Average annual landings	p.c.
	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968		
West Bengal & Orissa	631	806	1,616	2,205	3,793	2,317	2,133	1,887	7,744	10,872	3,400	4.01
Andhra	3,822	4,107	3,982	1,892	5,209	6,902	3,846	3,787	9,159	6,285	4,890	5.77
Madras	2,579	2,970	4,138	3,291	4,424	8,085	4,390	7,712	10,310	8,592	5,649	6.67
Kerala	14,684	12,781	20,541	29,240	22,044	35,292	14,541	28,936	27,310	25,521	23,089	27.25
Mysore	1,679	492	613	2,414	687	1,057	785	1,748	1,278	5,381	1,613	1.90
Maharashtra	31,565	43,931	29,956	41,804	42,528	43,643	50,266	43,311	36,547	41,621	40,517	47.82
Gujarat	12,254	5,307	3,215	2,350	3,669	2,162	4,455	4,616	4,083	3,721	4,583	5,41
Other areas	316	297	745	1,070	1,300	2*	1,476	2,643	789	1,290	9,913	1.17
Total	67,530	70,601	64,806	84,266	83,654	99,460	81,892	94,630	97,220	103,283	84,734	100.00

TABLE III

State-wise annual landings of penaeid prawns from 1959 to 1968

(landings in tonnes)

States/years	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	Aver-age	p.c.
West Bengal & Orissa	626	803	1,612	2,178	3,776	2,309	2,133	1,885	7,738	10,872	3,393	7.14
Andhra	1,836	1,591	2,797	1,305	3,476	5,229	3,507	2,999	6,886	5,784	3,541	7.45
Madras	1,634	1,872	1,819	2,526	3,265	3,958	2,189	5,136	6,365	5,044	3,382	7.11
Kerala	14,067	12,583	20,393	29,218	21,878	35,220	14,327	28,120	27,164	25,310	22,828	48.02
Mysore	1,601	420	545	2,379	647	1,040	778	1,696	1,260	5,364	1,573	3.31
Maharashtra	5,746	9,278	8,166	8,077	5,032	14,301	9,796	9,864	8,136	11,296	8,969	18.87
Gujarat	1,823	4,917	3,012	1,497	1,697	1,330	3,948	4,094	3,653	3,221	2,919	6.14
Other places	299	295	739	1,070	1,300	2	1,398	2,352	663	1,211	933	1.96
Total	27,632	31,759	39,083	48,251	41,071	63,389	38,085	56,146	61,865	68,102	47,538	100.00

TABLE IV

State-wise annual landings of other crustaceans from 1959 to 1968

(landings in tonnes)

States/Years	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	average	p.c.
West Bengal & Orissa	1	3	4	-	-	8	-	2	6	-	2	0.06
Andhra	1,118	1,423	496	213	853	468	9	162	2,240	159	714	23.53
Madras	761	823	1,311	755	1,058	3,982	2,110	2,443	3,794	3,150	2,019	66.52
Kerala	117	175	105	22	90	72	130	557	58	176	150	4.94
Mysore	78	72	58	35	40	17	7	52	18	16	39	1.29
Maharashtra	16	48	46	2	14	18	58	135	35	14	39	1.29
Gujarat	-	25	13	4	6	-	-	74	14	1	14	0.46
Other places	2	2	5	-	-	-	78	291	126	79	58	1.91
Total	2,093	2,571	2,038	1,031	2,061	4,565	2,392	3,716	6,291	3,595	3,035	100.00

TABLE V

State-wise annual landings of non-penaeid prawns from 1959 to 1966

(Landings in tonnes)

States/years	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	Average	p.c.
West Bengal & Orissa	4	-	-	27	17	-	-	-	-	-	5	0.01
Andhra	868	1,003	689	374	880	1,205	330	626	33	342	635	1.86
Madras	184	275	1,008	10	101	145	82	123	151	398	248	0.72
Kerala	500	23	43	-	76	-	84	259	88	35	111	0.33
Mysore	-	-	10	-	-	-	-	-	-	1	1	-
Maharashtra	25,803	34,605	21,744	33,725	37,482	29,324	40,412	33,312	28,376	30,311	31,509	92.24
Gujarat	10,431	365	190	848	1,966	832	507	448	416	499	1,650	4.83
Other places	15	-	1	-	-	-	-	-	-	-	2	0.01
Total	37,805	36,271	23,685	34,984	40,522	31,506	41,415	34,768	29,064	31,586	34,161	100.00

TABLE VI

Composition of average penaeid prawn landings

States	W.Bengal & Orissa	Andhra	Madras	Kerala	Mysore	Maharashtra	Gujarat	Other States	Total	p.c. to penaeid landings	p.c. to total crustacean landings
Penaeus semisulcatus	83	81	312	-	-	-	-	-	476	1.00	0.56
P. merguensis	285	341	-	-	11	-	-	-	637	1.34	0.75
P. indicus	179	189	1,529	3,578	77	-	-	-	5,552	11.68	6.55
P. monodon	355	355	499	112	-	-	-	-	1,321	2.78	1.56
P. penicillatus	-	-	-	-	-	-	86	-	86	0.18	0.10
Metapenaeus dobsoni	195	169	518	14,559	631	-	-	-	16,072	33.81	18.97
M. affinis	413	352	27	212	303	2,172	1,111	-	4,590	9.66	5.42
M. monoceros	442	459	492	12	8	497	183	-	2,093	4.40	2.47
M. brevicornis	1,441	1,595	-	-	-	54	183	-	3,273	6.89	3.86
Parapenaeopsis stylifera	-	-	--	4,306	524	2,466	867	-	8,163	17.17	9.63
P. sculptilis	-	-	-	-	-	1,016	183	-	1,199	2.52	1.42
P. hardwickii	-	--	-	-	-	1,720	-	-	1,720	3.62	2.03
P. uncta	-	-	-	-	-	-	123	-	123	0.26	0.15
Solenocera indicus	-	-	-	-	-	455	183	--	638	1.34	0.75
Unidentified	-	-	5	49	19	589	-	933	1,595	3.35	1.88
Total	3,393	3,541	3,382	22,828	1,573	8,969	2,919	933	47,538	100.00	56.10

TABLE VII

Composition of average non-penaeid prawn landings

States	W.Bengal & Orissa	Andhra	Madras	Kerala	Mysore	Maharashtra	Gujarat	Other states	Total	Percentage to non-penaeid landings	Percentage to toal crustacean landings
Acetes indicus	-	-	240	111	-	13,163	-	-	13,514	39.56	15.95
Acetes spp.	-	635	-	-	-	-	365	-	1,000	2.93	1.18
Palaemon tenuipes	-	-	--	-	-	5,769	342	-	6,111	17.89	7.21
P. styliferus	-	-	-	-	--	3,594	342	-	3,936	11.52	4.65
Palaemon spp.	--	-	8	-	-	-	-	-	8	0.02	0.01
Hippolysmata ensirostris	-	-	-	-	-	1,796	601	-	2,397	7.02	2.83
Unidentified spp.	5	-	-	-	1	7,187	-	2	7,195	21,06	8.49
Total	5	635	248	111	1	31,509	1,650	2	34,161	100.00	40.3

TABLE VIII

Composition of average landings of other crustaceans

Panilurus spp.	-	-	82	53	-	2	-	-	137	5.51	0.16
Neptunus sp.	--	708	1,817	97	17	32	-	-	2,671	88.01	3.15
Scylla spp.	-	6	120	-	1	-	-	-	127	4.18	0.15
Others	2	-	-	-	21	5	14	58	100	3.30	0.12
Total	2	714	2,019	150	39	39	14	58	3,035	100.00	3.58

XI GENERAL OBSERVATIONS

By

S. Jones

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XI GENERAL OBSERVATIONS

S. Jones

From the foregoing sections it may be seen that against the back-ground information on the biology and resources of the prawn species now available, an attempt is made to give a comprehensive account of the present status of their fishery in India which ranks pre-eminently high among the shrimp-producing countries of the world. There has been no intention to give a complete account of the varied items of prawn investigations undertaken at this Institute and other organisations in this region but to sieve out and highlight only the basic facts which are relevant to the exploitation and management of the resources.

The more important prawn species supporting fisheries in this region have been fairly well-known since the pioneering work of Alcock and Anderson (1894). Yet, in respect of a large number of prawn species, there has been a great deal of confusion of their synonimies and nomenclature. Some of the penaeid prawns now regarded as belonging to distinctly separate species were clubbed along with closely related forms. A real break through has been effected when the Central Marine Fisheries Research Institute undertook the crustacean fishery investigations over two decades ago. At the very outset all the commercial species have been carefully re-examined, identified and systematically classified establishing their synonimies. Since then more and more species hitherto not known from the seas around India have been reported upon. This only shows that our knlowledge of the species abundance in this region is far from complete. We are dealing with a group, most of the member species of which have an extensive range of distribution over the entire Indo-Pacific region and it is therefore not surprising that almost any exploratory survey carried out especially in deep waters brings to light some interesting forms which commonly occur elsewhere in the Indo-Pacific. With the present back-ground information on the subject and the well-trained personnel readily available, it

should be possible to devote some attention in future too to study the systematics, for this knowledge is pre-requisite to any biological investigation It is needless to say that biological investigations are of little value if they are riddled with taxonomic inaccuracies arising out of mistaken identity of the concerned species.

Of primary importance in the estimation of resources are the catch statistics which the Institute has been able to furnish not only in respect of prawns but also of all other groups in the marine fish landings. The regional distribution pattern of the penaeid and non-penaeid groups of prawns has been studied and their seasonal fluctuations have been assessed. The production trends of crustaceans, especially prawns in our marine fish landings are comparatively more stable than those of some of our pelagic fish species like the oil sardine and the mackerel which are subject to violent and unpredictable fluctuations. In the ten year period of 1959-1968 the annual averages of the penaeid prawns, the non-penaeid prawns and other crustaceans have formed 47,538 (56.10%), 34,161 (40.32%) and 3,035 (3.58%) metric tons respectively, the total crustaceans amount to 84,734 metric tons comprising 10.89% of the annual average of all marine fish estimated at 777,733 metric tons. In the state-wise landings, Maharashtra has ranked first contributing to the extent of 47.82%, Kerala 27.25%, Tamil Nadu (Madras) 6.67%, Andhra 5.77%, Gujarat 5.41%, West Bengal and Orissa 4.01%, Mysore 1.90% and other areas 1.17% to the total crustaceans. More than 85% of the prawn catch comes from the west coast landing centres.

The penaeid prawns are generally of large size and are of higher value than the non-penaeid prawns as the former are in great demand by the processing concerns that cater to the needs of foreign markets. Although Maharashtra's prawn landings are the highest among those of the maritime states, the bulk of the catch i.e., 77.77% is formed of non-penaeid species and only 22.13% of the penaeid forms. Kerala's prawn production is very important as the penaeid prawns in the region constitute 98.87% of the total crustacean landings.

In the All-India annual average landings of penaeid prawns in the past ten years, among the important ones, Metapenaeus dobsoni has formed 33.81%, Parapenaeopsis stylifera 17.17%, Penaeus indicus 11.68%,

Metapenaeus affinis, 9.66%, M. brevicornis 6.89%, M. monoceros 4.40%, Parapenaeopsis hardwickii 3.62%, P. ~~[illegible]~~ sculptilis 2.52%, Penaeus ~~[illegible]~~ monodon 2.78%, Solenocera indicus 1.34%, and Penaeus merguiensis 1.34%. P. semisulcatus and P. penicellatus have formed less than 1% each. Among the non-penaeid varieties Acetes spp. have constituted 39.56%, Palaemon tenuipes 17.89%, P. styliferus 11.52% and Hippolysmata ensirostris about 7%.

In the past two decades, the exploratory fishing vessels of the Government of India surveyed vast regions on the continental shelf both on the east coast and the west coast and helped the Institute to furnish valuable information on the potential prawn resources and their seasonal abundance. The results of these on careful analyses present a clear picture of the distribution pattern of the prawn resources covering different depth ranges across the shelf. A large number of very productive areas have been discovered where the catch rates obtained have proved to be extremely high. In the execution of the collaborated programmes of this Institute with the governmental organisations, fairly extensive deep sea prawn beds beyond the 100 fathom line on the continental slope and in still deeper regions have been discovered off the southwestern coast and these hold promise of supporting fisheries of some magnitude, if carefully exploited. In this connection, it is worth noting that the exploratory fishing by R.V. Varuna in depth ranges of 275-375 metres around latitudes 10° 41' N to 10° 53' N and longitudes 75° 08' E to 75° 21' E has revealed good concentrations of Aristeus semidentatus, a fairly large sized prawn suitable for export trade. Penaeopsis rectacutus, Heterocarpus spp., Parapandalus spinipes and Plesionika spp. have also been recorded in fairly high concentrations in adjacent deeper waters.*

While the exploratory surveys carried out have indicated the possible prawn resources in certain regions, by far vast areas on the continental shelf and on the slope beyond remain unexplored. As the ten mile wide coastal belt at present is very regularly and intensively exploited, the future scope for expansion of prawn fisheries depends to a large extent on the as yet untapped resources of the shelf and the slope.

* Silas, E.G. 1969: Bull. cent. mar. Fish. Res. Inst., No.12.

Biological information on age and rate of growth, food and feeding habits, maturation and spawning of almost all the penaeid prawns and some of the palaemonid species has been gathered in some detail. All penaeid prawns of our coasts are known to breed in the sea. While the larvae and juveniles of Parapenaeopsis stylifera remain in the sea for further growth and sexual maturity, those of the other penaeid prawns ~~enter~~ enter the backwaters and estuaries where they feed and grow for some months and return to sea for further growth, sexual maturity and breeding. Whether it is essential for the juveniles of the penaeid prawns to enter the backwaters and the estuaries to spend a part of their life is not fully known. The factors determining their migrations are as yet little understood. From the study of the distribution of the mature and spent individuals it appears that each species shows a preference to certain specified depth zones.

There is paucity of information on the embryonic and early larval development in regard to many of the marine prawn species of the family penaeidae, because of the attendant difficulties in rearing them under laboratory conditions, but in most cases the planktonic larvae have been traced through successive stages and compared and connected with the adult. Of the penaeid prawns the life history of Metapenaeus dobsoni which is the most important of the commercial species has been worked out in great detail at this Institute. The diagnostic characteristics of the post-larvae of Penaeus indicus, M. monoceros, M. affinis, M. dobsoni and Parapenaeopsis stylifera have been studied and keys to their identification have been prepared; information on the postlarvae of the less common penaeidae like Solenocera indica is also now available. It is gratifying to note that almost all the planktonic larvae of the commercially important prawns can readily be identified with the available information on the subject. Information regarding members of the palaemonid group is more complete on account of the comparative ease with which the early developing stages could be handled under confined conditions for observations. Investigations carried out over a period of some years have shown that the larval and postlarval abundance of certain penaeid prawn species provides an index to determine the magnitude of the forthcoming prawn fisheries in the coastal waters of Cochin.

In regard to Macrobrachium rosenbergii the breeding grounds have been observed in slightly saline waters of the Vembanad Lake in Kerala and the nursery grounds for the young in the river system debouching into it. These findings help to promote cultural practices with the readily available stocks of young ones from sources now known. This, with transplantation of the adults or the young ones to other river systems helps appreciably in increasing prawn production.

Prawn trapping in paddy fields which are subject to tidal flow has been in practice on an extensive scale in Kerala. The major portion of the prawn catch is composed of small juveniles, the demand for which in recent years has decreased considerably with the increasing demand for larger-sized ones by the export trade in frozen prawn. However, experimental observations have shown that these fields not merely help capture of prawns but also provide suitable biological environment for life and growth of the juvenile prawns and that culturing the juveniles under such conditions for about a month could result in relatively better catches of larger-sized prawns. The knowledge so far obtained on prawn rearing should assist in undertaking cultural practices on a large scale, utilizing the low lying shallow coastal lagoons and backwaters as is being done in some of the southeast Asian countries.

Regarding environmental data, a certain amount of basic information on the hydrology and planktology of the waters over the shrimp beds has been collected. Seasonal catch trends have been correlated with cyclical changes in the environmental factors where possible. Particular attention has been given to the study of vertical acceleration of silt laden waters in the regions of "mud banks" during the south west monsoon period where dense congregations of prawns occur supporting fisheries of some magnitude. However, the available environmental data are still incomplete to interpolate the catch data and deduce the causative factors behind the seasonal and annual fluctuations.

The Institute has very early initiated investigations on chloride regulation in prawns with a view to studying adaptations to estuarine and brackish water conditions. The penaeid prawns have an osmotic behaviour similar to marine palaemonids. They have osmoregulatory powers, regulating the chloride content of the blood when they are in the

media of different salinities. The higher salt content of the blood of the palaemonids when compared to other invertebrates is a factor which determines their ability to enter the estuaries and brackish waters. It is also known that sexually mature individuals are less resistant to variations in salinity media. Thus, although a few basic facts about osmoregulation are known, information on varied aspects of crustacean physiology relating to growth, breeding and migration is still lacking. Marking and releasing experiments on some of the more important prawn species have been initiated and it is hoped that these would help in better understanding of the rate of growth, migrations etc.

In the pre-war years the export trade in shrimps from India fetching hardly a few million rupees consisted of sundried, 'semi-dried' and pickled products on a limited scale to the far eastern countries. In the early post-war period a new industry has sprung up for freezing and canning of shrimps and this has so rapidly advanced that India is now the second foremost among the shrimp exporting countries trading with the United States of America which is the world's largest importing country in processed shrimp. India has exported shrimp and shrimp products worth nearly 190 million rupees of foreign exchange in 1968. The industrial concerns who have invested substantial amounts on this business around Cochin, which is the most intensively fished region on our coast for prawns, have rightly an apprehension that the trade in the coming years might be shifted by the increasing competition particularly in the context of the fall in the catch per hour returns and reduction in the average size of the prawns obtained in recent years. Statistical observations so far made at this Institute have not indicated any signs of depletion. Variation in average size is dependent on fluctuation in relative abundance of the different species composing the catches. it may however be admitted that the fishing pressure is ever on the increase and probably we are almost reaching the optimumum level of exploitation in these most intensively fished areas. The effect of any further increase in fishing effort on the potential prawn resources in the region needs careful watching. In conclusion it may be said that our scientific investigations should be directed towards stabilizing the prawn yields in this region and cautioning the industry before it

is late to regulate fishing effort. Besides initiating commercial exploitation of the recently discovered prawn grounds in the deeper waters of the shelf and the slope, a surer approach to step up production is the intensification of fishing effort in grounds other than those around Cochin, viz., those in the central and northern regions on thewest coast and around the estuaries and the vicinities of backwaters along the east coast. There is also the need, as stated earlier, for conducting exploratory surveys for locating new prawn beds. The status of the prawn fishing industry is eminently high at present and the prospects for expansion in future are yet brighter for we are coming to know more and more about the distribution and magnitude of the currently exploited as well as the untapped resources, against an increasing knowledge of the biology of species supporting the fisheries.

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APPENDIX

Export of Shrimp and Shrimp Products from India during 1960-1968

Year		Frozen Prawns	Canned Prawns	Dried prawns	Other prawn products*	Total
1960	Q	1,211,165	319,510	-	-	1,530,675
	V	5,866,123	1,784,047	-	-	7,650,170
1961	Q	1,462,656	621,773	-	-	2,084,429
	V	7,366,872	4,222,907	-	-	11,589,779
1962	Q	2,238,190	969,923	-	-	3,208,113
	V	10,820,276	6,558,924	-	-	17,379,200
1963	Q	3,966,899	1,231,274	2,808,675	255,015	8,261,863
	V	21,203,766	7,575,594	9,324,698	84,363	38,104,058
1964	Q	5,870,031	1,073,927	3,008,650	511,870	10,464,478
	V	31,518,242	6,991,927	8,996,764	128,573	47,635,506
1965	Q	7,028,121	1,148,002	1,702,270	104,896	9,983,289
	V	41,421,834	9,505,799	5,446,894	69,728	56,444,255
1966	Q	8,783,545	1,523,327	1,463,142	83,269	11,853,283
	V	88,791,851	18,656,606	5,270,682	65,983	112,785,122
1967	Q	11,173,489	2,200,383	1,540,089	127,156	15,041,117
	V	129,808,364	31,243,273	8,961,115	128,573	170,141,325
1968	Q	14,397,425	2,237,923	1,410,759	13,647	18,059,754
	V	156,340,498	26,156,195	7,258,581	84,971	189,840,245

Q - Quantity (in kg); V- Value (in Rupees).
Source: Marine Products Export Promotion Council, Ernakulam.

*Prawn powder and prawn pickles.